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COSAL--A BLACK-BOX COMPRESSIBLE STABILITY ANALYSIS CODE FOR TRANSITION PREDICTION IN THREE-DIMENSIONAL BOUNDARY LAYERS

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SUMMARY

A fast computer code COSAL for transition prediction in three-dimensional boundary layers using compressible stability analysis is developed. The compressible stability eigenvalue problem is solved using a finite-difference method and the code is a black-box in the sense that no guess of the eigen-value is required from the user. Several optimization procedures are incorporated in COSAL to calculate integrated growth rates (N factor) for transition correlation, for swept and tapered laminar flow control wings, using the well known e^N method.

The optimization procedures incorporated in COSAL have been derived from SALLY code developed by Drs. Andrew Srokowski and Steven Orszag. COSAL was developed under NASA contracts NAS1-15604 and NAS1-16572.

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1. INTRODUCTION

The stability properties of compressible laminar boundary layers are particularly relevant to the phenomenon of laminar-turbulent flow transition. Recently, interest in this problem has increased because of applications to Laminar Flow Control (LFC) technology. In such applications there is a need for fast computer codes to perform efficient design calculations. The computer code COSAL (Compressible Stability Analysis) has been developed for this purpose. It can perform optimized stability calculations for general parallel flows over swept wings.

The linear stability analysis of three-dimensional compressible boundary layers involves solution of an eigenvalue problem for an eighth-order system of differential equations. In the case of two-dimensional boundary layers or in the absence of dissipation in three-dimensional flow, the eighth-order system reduces to the sixth order.

The basic equations for the linear stability analysis of parallel-flow compressible boundary layers are derived using small disturbance theory. Infinitesimal disturbances of sinusoidal form are imposed on the steady boundary layer flow and substituted in the compressible Navier-Stokes equations. Assuming that the mean flow is locally parallel, a set of five ordinary differential equations is obtained. Of these, there are three second-order momentum equations, one second-order energy equation and one first order continuity equation. Most commonly, this system is reduced to a set of eight first order ordinary differential equations

making the system amenable to initial-value numerical integration procedures. Mack [1], for example, makes use of the initial value approach for the solution of the compressible stability eigenvalue problem.

In the computer code COSAL, a finite-difference method, developed by Malik and Orszag [2], is incorporated for the solution of the compressible stability equations. The stability equations are solved in their original form (3 second-order momentum equations, one second order energy and one first-order continuity equation). The code includes two eigenvalue search procedures— global (which is used when no guess is available) and local (which is used when a good guess is available). The local eigenvalue search procedure used in the code is significantly faster than the initial value approach employed by previous investigators.

COSAL is specifically designed to compute the compressible linear stability characteristics, and integrate the amplification rates (N factor) of boundary layer disturbances on swept and tapered wings. In three-dimensional layered flow, such as that on a wing, the dispersion relation is given by the complex relation

$$\omega = \omega \quad (\alpha, \beta) \tag{1}$$

where the α, β and ω are, in general, complex. Therefore, there are four arbitrary real parameters among α, β, and ω. There are several ways to remove this arbitrariness [3]. In our analysis we choose to use temporal stability theory in which α, β are real and ω is complex. It is thus assumed that the wavelike disturbances have x and z (see Fig. 1) components of waves number α and

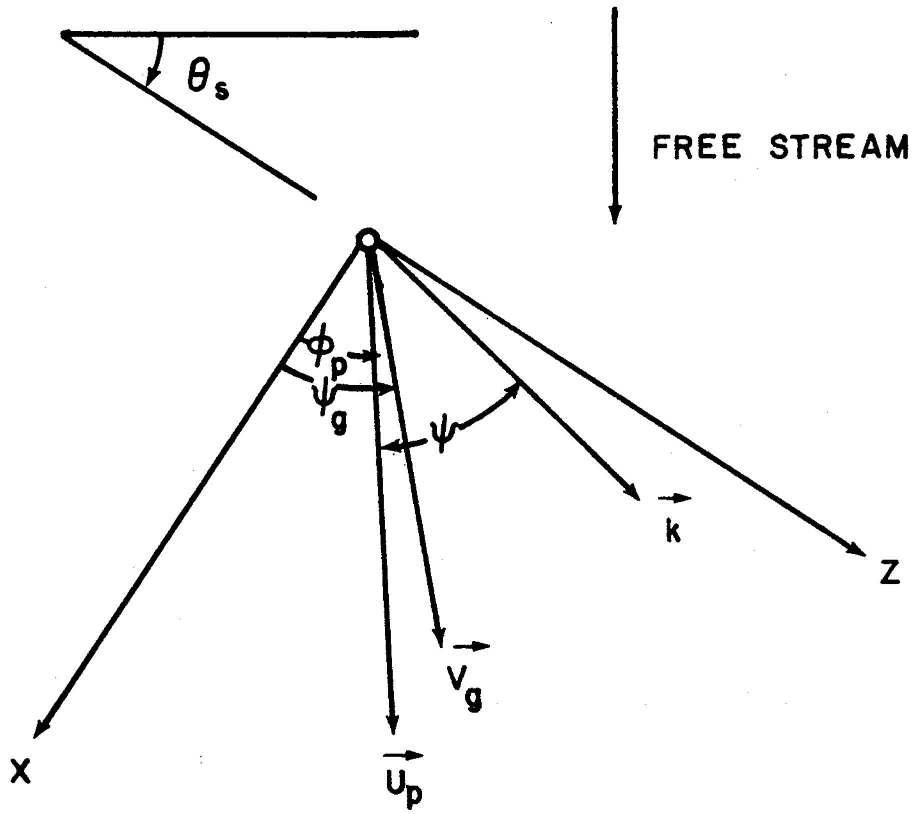

FIGURE 1. SWEPT (SWEEP ANGLE θ_s) COORDINATE SYSTEM; $\vec{U}_p$, $\vec{k}$, AND $\vec{V}_g$ REPRESENT THE POTENTIAL FLOW VELOCITY, THE WAVE NUMBER, AND THE GROUP VELOCITY VECTORS RESPECTIVELY.

β, respectively, and have a frequency $\omega_r = \mathrm{Re}(\omega)$. It is further assumed that the disturbances grow or decay only in time. They grow if $\omega_i = \mathrm{Im}(\omega) > o$ and decay if $\omega_i < o$. An N-factor for transition correlation may be defined as

$$N = \int_{s_C}^{s_T} \frac{\mathrm{Im}(\omega)}{|\mathrm{Re}(\vec{V}g)|} \, ds \tag{2}$$

where $\vec{V}g = \left(\frac{\partial\omega}{\partial\alpha}, \frac{\partial\omega}{\partial\beta}\right)$ is the (complex) group velocity and s is the arc length along an appropriate curve on the wing. Subscripts C and T indicate critical (linearly unstable) and onset of transition, respectively.

The N-factor (2) is not fully defined until a prescription is given for singling out a specific mode at each position on the wing and for defining a specific curve on which to integrate. We choose to integrate along the curve whose tangent is defined by the real part of the group velocity vector.

Four different methods are provided in COSAL to prescribe the mode whose growth is integrated to calculate N-factor. These are

1) Envelope method

Specify the real frequency ω_r and maximize the growth rate ω_i with respect to the disturbance wave numbers α, β.

2) Fixed wavelength and orientation method

Specify the disturbance wavelength $\lambda \propto \frac{1}{\sqrt{\alpha^2 + \beta^2}}$ and the orientation ψ.

3) Fixed wavelength and frequency method

Specify the disturbance wave length λ and the real frequency ω_r.

4) <u>Fixed orientation and frequency method</u>

Specify the disturbance orientation ψ and its frequency ω_r.

The user has to choose any one of the above methods and COSAL will calculate the N factor. The good news for the user's of incompressible stability analysis code - SALLY [4] is that COSAL accepts almost the same inputs as SALLY.

2. COSAL USER'S GUIDE

2.1 Program Cosal

The computer code COSAL is specifically designed to compute the compressible linear stability characteristics and integrate the amplification rates of boundary layer disturbances on swept and tapered wings.

The coordinate system used in COSAL is given in Fig. 2. The boundary layer profile data is input to COSAL on a constant radius, $r=r_o$, (see Fig. 2). The integration of the disturbance amplification rate is performed on a trajectory defined by the real parts of the (complex) group velocity vector $\vec{V}g$ (see Fig. 3). Since the conical flow assumption (see Section 3.1) is used in calculating the boundary layer profiles, the desired boundary layer data at radii other than r_o are calculated inside COSAL using conical flow similarity transformations.

The COSAL code employs two different procedures for the solution of the compressible stability eigenvalue problem— a global method which is used when no guess of the eigenvalue is available (e.g., when solution is started) and a local method which is used when a good guess of the eigenvalue is available.

A second-order accurate finite-difference representation of the compressible stability equations is employed which results in a block-tridiagonal system of equations. A generalized matrix eigenvalue problem is then set up and solved using the complex

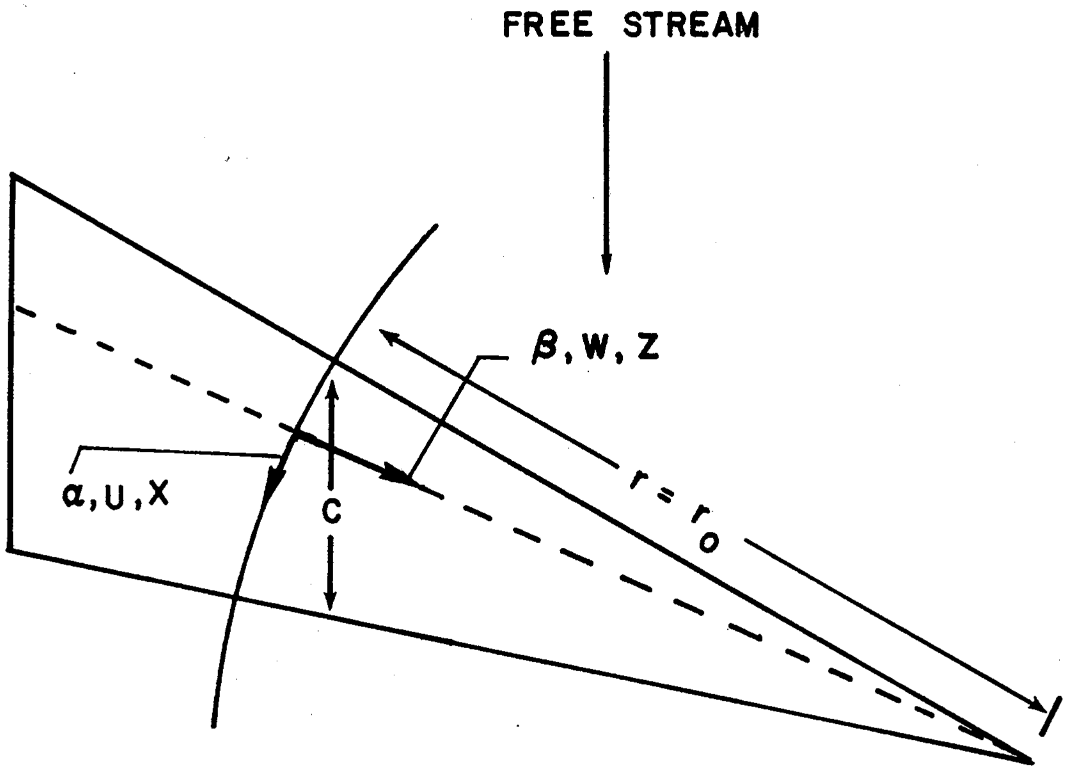

FIGURE 2. COORDINATE CONVENTIONS USED BY PROGRAM COSAL.

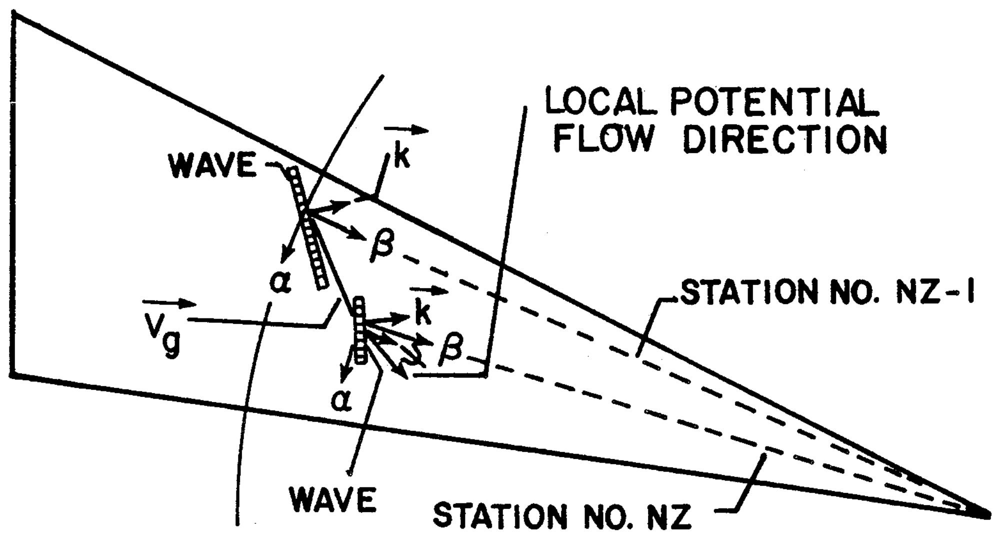

FIGURE 3. SCHEMATIC OF INTEGRATION PATH USED FOR CALCULATING N FACTORS.

LR algorithm [5] for global eigenvalue search. The local search is performed by inverting the block-tridiagonal system using block LU factorization together with the inverse Rayleigh iteration [5] procedure in which the eigenvalue, eigenfunction and its adjoint are obtained simultaneously. The group velocities are obtained at little extra cost to the local eigenvalue search. The accuracy of the local eigenvalue and group velocity is enhanced using Richardson's extrapolations. The resulting values are fourth order accurate. More detail of the numerical scheme is given in [2].

2.2 Computer Resources

The storage requirements of COSAL are largely governed by the desired accuracy in the global eigenvalue solution. When the global eigenvalue problem is solved using the LR algorithm, the storage requirements are of $O(K^2)$ while the computational work involved is of $O(K^3)$ where $K=5L$ (L being the number of subdivisions of the computational domain) for the eighth order system of equations and $K=4L$ for the sixth order system. Comparatively, the solution of the local eigenvalue problem using the present method requires only $O(K)$ storage and $O(K)$ work. It is important therefore to use the global method only when necessary. The COSAL code is designed in such a way that it solves the global problem only when no guess is available during integration of the disturbance amplification rates. In the present version of the code $K=100$ for the global problem which allows $L=20$ for the eighth order system and $L=25$ for the sixth order system. The storage requirements for the COSAL code

are 170, 000 octal words on CYBER 175. Since the global method is used only to provide a guess of the eigenvalue, the loss of accuracy using L=20 is not considered a deficiency of the code. If, however, the increased accuracy in the global solution is needed the code could be modified by changing two Fortran statements in the main program (see below). A maximum of K=160 can be used which would allow L=32 for the eighth order system and L=40 for the sixth order system. The storage requirements for K=160 case would be about 270,000 octal words.

The following changes would be required in COSAL if K=160 is to be used:

The dimension statement in the present version

```
      .
      .
COMPLEX AC(100,100), EIGA(100)
      .
      .
```

should be changed to

```
      .
      .
COMPLEX AC(160,160), EIGA(160)
      .
      .
```

And the data statement

```
            .
            .
. . . . . NDIM/100/. . . . .
            .
            .
```

should be changed to

```
            .
            .
. . . . . NDIM/160/. . . . .
            .
            .
```

Mack [6] reported that for transonic flows the difference between the results of the sixth-order system and those of the eighth order system is small. This was also confirmed by the calculations performed using COSAL. It therefore is desirable to use the sixth-order system for the global eigenvalue problem which is solved only to provide a guess. Some computer timings for the global method on a CYBER 175 computer are given in Table 1. All timings were obtained using the internal clock and are averaged over three different test cases for a swept wing.

The maximum number of subdivisions allowed for the local eigenvalue solution is 100 (the storage requirement remains 170,000 octal) in the present version of the code. The accuracy of the local eigenvalue and the group velocity is increased by use of Richardson's extrapolations. The maximum number of subdivisions in these extrapolations should not increase L=100. Some data on the speed of local eigenvalue solution are given in Table 2.

The overall time required by COSAL code depends obviously upon the desired option and the number of stations to be used in search of instabilities. The execution time for test case No. 4 (see Section 2.4 below) was about 180 seconds.

Table 1 Timings for the global eigenvalue method (time given in seconds on a CYBER 175 computer).

L	8th order system	6th order system
15	3.15	2.05
20	7.12	5.17
25	13.47	8.65

Table 2 Timings for the local eigenvalue method

L	8th order system	6th order system
20	0.61	0.40
40	1.14	0.77
80	2.22	1.52

2.3 Input/Output

The program card (for CDC machines) reads:

```
PROGRAM COSAL (INPUT, OUTPUT, TAPE5=INPUT, TAPE6=OUTPUT,
               TAPE7)
```

TAPE5 and TAPE6 are input and output units respectively, while TAPE7 contains the boundary layer profile data generated elsewhere for stability analysis.

The control cards needed to run COSAL are

```
    .
    .
(USER INFORMATIONS)
    .
    .
GET, COSAL.
FTN,I=COSAL, OPT=2.
GET,TAPE7=BLDATA.
LDSET,PRESETA=NGINF.
LGO.
EXIT.
7/8/9 End of record
$CARDIN
Input data
$END
6/7/8/9 End of file
```

COSAL reads user supplied input through Namelist $CARDIN. All other inputs are read from file TAPE7, generated by the boundary layer program WING. Except for a few additional parameters, the inputs to COSAL are the same as for SALLY. The default values for these additional parameters (which will be appropriate in most cases) will allow COSAL to be used with exactly the same inputs as for SALLY. Variables appearing in $CARDIN are described below.

ALPHA	Non dimensional wave number component
ALPX	Series of ALPHA values is input into this array (specify with IAB = 1)
BETA	Non dimensional wave number component. (Note: ALPHA and BETA need only be input if IBEGIN = 1 and ITRIV = 1 are selected or if IAB = 0 and ITRIV = 0 are selected.)
BETX	Series of BETA values is input into this array (Specify with IAB = 1)
IAB	Flag which specifies which of several options for a simple eigenvalue computation at a single station will be selected (default = 0)
IAB = 0	Input ALPHA and BETA will be used for simple eigenvalue computation
IAB = 1	String of input ALPHA, BETA pairs will be used for string of simple eigenvalue computations. Limit of 10 (Input through ALPX, BETX arrays)

IAB = 2	One input wavelength-to chord (XLENC) value will be used with input values of PSI for a string of simple eigenvalue computations (limit of 10 PSI values). ALPHA and BETA will then be computed by the program. ITRIV = 0 needs to be input for any of the IAB options to be executed. (NPSI also needs to be input)
IBEGIN	Flag which determines whether input ALPHA and BETA will be used to make a wavenumber for initial instability search, for ITRIV = 1 option. (default = 0)
IBEGIN = 1	Input ALPHA and BETA will be used to make wave number. Program will proceed from station NSTART to search for unstable mode for wavenumber obtained from input ALPHA and BETA. (Specified only with ITRIV = 1) IBLIND must be set to zero if IBEGIN is set to one.
IBEGIN = 0	Disables the option.
IBLIND	Flag which determines starting mode for ITRIV = 1. (default = 1)
IBLIND = 0	At station NSTART, an ALPHA BETA combination that yields a good unstable mode is known. This ALPHA and BETA combination must be input. If IBEGIN is set to one, and IBLIND is set to zero, program will execute as described under IBEGIN = 1.
IBLIND = 1	ALPHA and BETA for unstable mode is not known. User should input range of XLENC and specify value of PSI (input or default). Program will search for unstable modes automatically within the specified PSI-XLENC matrix. If IBLIND = 1 is selected, IBEGIN must be set to zero.

ICHEB	Flag which specifies how number of node points is to be determined for finite-difference solution. (default = 2)
ICHEB = 0	NCHEB node points will be used and increased to satisfy accuracy tests
ICHEB = 1	Default number of node points will be used and increased to satisfy accuracy tests
ICHEB = 2	NCHEB points will be used for all stations and not changed.
ICON	Flag which determines the number of stable regions through which computation will be allowed. (default = 1)
ICON = 0	Program will terminate computation upon encountering first stable region
ICON = 1	Program will continue through first stable region and will pick up computing a second unstable zone, if one exists. Program will terminate upon encountering second stable region. N factor will be reset to zero upon encountering second unstable zone.
ICON = 2	Program will compute through all stable-unstable regions
IPR1	Flag which controls the print of mean flow profiles as provided through TAPE 7. (default = 0) Note: Print flags set to 1 enable printing. Print flags set to 0 disable printing.
IPR2	Flag which controls print of eigenvalue spectrum from the global eigenvalue calculation. (default = 0)

IPR3	Flag which controls print of local eigenvalue search iterations. (default = 0)
IPR4	Flag which controls print of eigenfunction (default = 0)
IPR5	Flag which controls print of boundary layer profiles which have been interpolated to the grid desired for computations. (default = 0)
IRP7	Flag which controls print of intermediate iteration results. Useful for diagnosing program malfunctions, but produces more information than is needed when running routine production jobs. (default = 0)
IPRZ	Flag which determines if the accuracy of local eigenvalue and group velocity will be increased using Richardson's extrapolation. Non-zero IPRZ will triger extrapolation using NCHEB, (NCHEB + IPRZ), and (NCHEB + 2 * IPRZ) points. ((NCHEB + 2 * IPRZ) .LE.101). (DEFAULT IPRZ = 10))
IPRZ = 0	Richardson's extrapolation not used.
IPSI	Flag which determines whether default crossflow or streamwise angles, or the user input angles will be used for unstable mode search. (default = 0)
IPSI = 0	Default streamwise or critical crossflow angles will be used for unstable mode search.

IPSI = 1	User input angle PSI will be used as wave angle for unstable mode search.
ITRIV	Flag which specifies which of the major computing options is to be selected (default = 5)
ITRIV = 0	Simple eigenvalue computation at one station. (NSTAT = 0; NWANT must be given) IAB parameter must be set to execute desired option.
ITRIV = 1	Program will follow and integrate N factors for a disturbance of fixed frequency. Search procedure to maximize amplification will be implemented. IBLIND must also be set to 0 or 1. (See instructions for IBLIND)
ITRIV = 4	Program will follow and integrate N factors for a disturbance of fixed wavelength and orientation. (Relative to local free stream direction). Frequency of the disturbance changes. Amplification rates are not maximized. Only one value of PSI and XLENC may be input. NPSI and NXLEN must be set to 1. If IPSI = 0, default critical crossflow angle obtained at station NSTART will be followed all the way through.
ITRIV = 5	Program will follow and integrate N factors for a disturbance of fixed wavelength and frequency. Orientation of the disturbance changes. Amplification rates are not maximized.

ITRIV = 6	Program will follow and integrate N factors for a disturbance of fixed orientation and frequency. Disturbance wavelength changes.
ITYP	Flag which specifies whether computation is to be for crossflow or 2-D Tollmein-Schlichting type disturbances. (default = 0)
ITYP = 0	Crossflow Computation.
ITYP = 1	T-S computation.
M	Value of M determines the order of stability equations to be used in local eigenvalue search. (default = 5)
M = 5	The full 8th order stability equations will be solved.
M = 4	The reduced 6th order stability equations will be solved.
MG	Value of MG determines the order of stability equations to be used in global eigenvalue search. (default = 4)
MG = 5	The full 8th order stability equations will be solved.
MG = 4	The reduced 6th order stability equations will be solved.
NAB	Number of ALPX - BETX pairs (Limit of 10)
NCHEB	Number of node points to be used in local eigenvalue computation. (default = 21). For maximum allowable limit, see IPRZ.

NG	Number of node points used in global eigenvalue search, ((NG-1)*MG).LE.NDIM), (DEFAULT NG = 21). Note: As noted in section 2.2, the present version allows NDIM = 100. NDIM can be increased up to 160 as described in Section 2.2.
NINTEG	Flag which controls integration of the amplification rate (default = 2)
NINTEG = 0	No integration of amplification rate. Calculations will be performed along an arc of constant radius.
NINTEG = 1	Amplification rates will be integrated. Assumes zero amplitude at leading edge.
NINTEG = 2	Amplification rates will be integrated. If NR=0 then starting disturbance amplitude will be taken as one at station number = NZERO. (N-factor = 0) IF NR=1, this denotes a restart run which means that the N-factor, Reynolds number, displacement thickness, radius, ALPHA and BETA at the starting location must be input from the previous run. If NR=2 this is the same as (NR=0) except that NZERO is set internally to be the station immediately before the first one for which good unstable modes are found.
NPSI	Number of values being input into PSI array. (default = 1, maximum is 10)

NR	Flag used in conjunction with NINTEG; NR specifies whether or not a restart is being attempted. (see additional instructions under NINTEG); (default = 2).
NR = 0	Not a restart.
NR = 1	This is a restart run. Note: NR=1 restart option can only be used for ITRIV=1 with NINTEG=2.
NR = 2	Not a restart.
NSTART	Station number at which to begin computation for multiple station computation.
NSTAT	Flag which specifies whether only one station is to be computed (default = 1)
NSTAT = 0	Only one station desired. (NWANT must be input) Set for ITRIV .EQ. 0
NSTAT = 1	More than one station desired. NSTART and NSTOP must be input. Set for ITRIV .NE. 0
NSTOP	Station number at which to end computation.
NWANT	Station number when only one station is to be computed. (default = 0)
NXLEN	Number of input values of XLENC (ITRIV = 0;4: Limited to 1) (ITRIV = 5; Limited to 1), (ITRIV = 1;6: Limited to 5) (default = 1)
NZERO	Station number at which initial disturbance amplitude is to be taken as 1, and the N FACTOR = 0. (default = 2). NZERO needs to be specified only if NR = 0. See more information under NINTEG.

PSI — Angle of the normal to the disturbance wave front measured positive counterclockwise from local free stream direction. (PSI array is zeroed out in data statement. PSI is input in degrees). NPSI values may be input. For ITRIV = 0;5 NPSI is limited to 10. For ITRIV=1 or 4 or 6, NPSI is limited to 1.

RFREQ — Physical frequency of disturbance which COSAL is to follow. (hertz) (default = 0.5 HZ)

XLENC — Ratio of disturbance wavelength to wing chord. (default = .0005)

YEDGE — Edge of the boundary layer for stability calculations, y_e^*/δ^*. A relatively large ETAE is needed since disturbances are assumed to vanish at the outer boundary in global eigenvalue search. (In local calculations, however, asymptotic boundary conditions are imposed at the outer boundary and a smaller value can be used). The default value will be adequate in most situations (default = 100.0)

The following parameters are required when a restart is attempted (with ITRIV = 1) using the NR = 1 option. Values of parameters are taken from a solution station where a good unstable mode has previously been found. NSTART has to be set to the station number from which restart parameters have been taken.

DSTZIN	Restart displacement thickness
RADIN	Restart radius
REYIN	Restart Reynolds number
XNIN	Restart N FACTOR

Additionally, ALPHA and BETA values corresponding to the last good solution must be input. IBEGIN and IBLIND must be set to zero.

Description of Output

The output of COSAL is, in general, self-explanatory. Some of the FORTRAN variable names are described here.

DSTZ	δ^*, displacement thickness used as a length scale
ALPHA	α, non-dimensional wave number in the x-direction (Fig. 2). The wave number is non-dimensionalized with the displacement thickness of the velocity profile in x-direction.
BETA	β, non-dimensional wave number in the Z-direction.
OMEGA	ω, non-dimensional complex frequency. $\omega = \frac{2\pi\delta^*}{U_e}\omega^*$ where ω^* is dimensional frequency in Hertz and δ^* and U_e are the displacement thickness and edge value of the x-component of velocity.
VA	$\frac{\partial\omega}{\partial\alpha}$, non-dimensional (complex) group velocity component in x-direction.

VB	$\frac{\partial\omega}{\partial\beta}$, group velocity component in Z - direction.
PHI	ϕ, angle of the local potential flow velocity vector with the x-axis. ($\phi = \tan^{-1} \frac{W_e}{U_e}$)
PSI	ψ, wave angle with respect to the local potential flow velocity vector. ($\psi = \tan^{-1} \frac{\beta}{\alpha} - \phi$) ψ is taken positive in the counterclockwise direction.
XLENC	λ/c, ratio of the wavelength to the airfoil chord.
FREQ	Real (ω), non-dimensional disturbance frequency.
RFREQ	Real (ω^*), physical disturbance frequency (HZ).
N FACTOR	Logarithmic exponent of disturbance amplitude ratio ($N = \log_e A/A_o$)
ARG	Indicator of local growth rate. Specifically, ARG is the rate of change of N FACTOR with surface distance.
REY	R, displacement thickness Reynolds number. $R = \frac{U_e \delta^*}{\nu_e}$, where ν_e is the kinematic viscosity in the free stream.
MACH NO	M_e, edge Mach number. $M_e = \frac{U_e}{\sqrt{\gamma \Delta T_e}}$, where γ and Δ are the ratio of specific heats and the universal gas constant respectively and T_e is the free stream temperature.

2.4 Sample Test Cases

Sample inputs for some test cases are given below. These test cases are designed to bring to the user's attention the options available in COSAL.

Case No. 1

It is desired to obtain a simple eigenvalue computation for given wavenumber components ALPHA and BETA at station No. 10. Full eigenvalue spectrum from global calculation will be printed. The eigenfunction corresponding to the most unstable mode will also be printed. Inputs are:

NWANT = 10

NSTAT = 0

ITRIV = 0

ALPHA = .18

BETA = -.37

IAB = 0

IPR2 = 1

IPR4 = 1

In this example, the program is allowed to use the default number of node points (NG=NCHEB=21). The global calculation is made using the reduced sixth order system (MG=4) of equations. The negative of the (complex) global eigenvalue spectrum (a total of MG*(NG-2) + 1 values) is printed. The real and imaginary parts of an eigenvalue represents respectively the disturbance frequency and its temporal growth rate. In the printout of the full eigenvalue spectrum, a mode with a negative imaginary part is unstable.

The most unstable eigenvalue is selected from the spectrum and multiplied by (-1). The local eigenvalue search procedure is then used to increase the accuracy of this mode and obtain the corresponding eigenfunction and group velocities. The final OMEGA which is printed is the result of Richardson's extrapolation using 21, 31 and 41 node points. The group velocities VA and VB are also the extrapolated values. The printed eigenfunction is, however, that obtained using 41 points. Five components of eigenfunction printed are:

U - X component of the velocity perturbation

V - Y component of the velocity perturbation

P - pressure perturbation

T - temperature perturbation

W - Z component of the velocity perturbation

The eigenfunction can be printed only when the full eighth order system (M=5) is solved for local eigenvalue search.

Case No. 2

It is desired to obtain a simple eigenvalue computation for two sets of ALPHA-BETA pairs at station No. 10. It is also desired that the global solution be obtained for the eighth order system of equations using the default number of node points. The local solution will be obtained for the default value of NCHEB=21. However, the extrapolation parameter IPRZ is set to 20; so the final eigenvalue will be obtained by

Richardson's extrapolation using 21, 41 and 61 node points. For this case, the inputs are:

NWANT	=	10
NSTAT	=	0
ITRIV	=	0
ALPX	=	.18, .2
BETX	=	-.37, -.35
NAB	=	2
IAB	=	1
MG	=	5
IPRZ	=	20
IPR2	=	1

This example illustrates use of the IAB = 1 option. The IAB = 1 option permits the user to do a series of calculations of the type seen in Case No. 1. The pairs of ALPHA - BETA values for which computations are to be made are read in through the ALPX, BETX arrays. In this example two pairs of ALPHA-BETA values are used. The user can specify up to NAB = 10 values. The IAB = 1 option is particularly useful when the user wishes to construct a stability chart of a particular profile. Referring now to the printout, we see that the first pair of wavenumbers (ALPHA-BETA) is the same as for Case No. 1. In this case, however, MG = 5 is selected; so the global calculations are made using the eighth order system of equations. As the user can see, the calculated unstable eigenvalue is

slightly different from that calculated by the global method in the previous case where the default value of MG = 4 was used.

In the present case the local eigenvalue is obtained with increased number of points.

Case No. 3

Case No. 2 illustrated an option (IAB = 1) for obtaining stability results for a fixed location on the wing, when the user wishes to input wave number pairs. This is not always convenient. For example, a calculation might be needed where the user has a fixed wavelength disturbance, and wants to see what happens to the stability as the orientation angle changes. Using the IAB = 1 option requires the user to convert the physical wavelength and orientation angle to the wavenumbers (ALPHA - BETA). This is done automatically when the IAB = 2 option is selected. In the present example we use 3 orientation angles. However, up to 10 orientation angles can be specified. The global solution will be obtained using only 11 points. On the other hand, local solution will be obtained using 101 points and no Richardson's extrapolations will be performed. The inputs are:

NWANT	=	10
NSTAT	=	0
ITRIV	=	0
IAB	=	2
PSI	=	85., 87., 89.
XLENC	=	.00065

NPSI = 3

NG = 11

NCHEB = 101

IPRZ = 0

IPR2 = 1

This run demonstrates that since only a crude guess is required for the local eigenvalue search, the global solution can be performed with a small number of points.

Among other things, the present and the preceding two runs have shown how the number of node points can be changed or how the selection of the order of the stability equations is made. In the following runs only the default values of the control parameters M, NCHEB, MG and NG will be used.

Case No. 4

This test case computes N FACTOR for cross flow disturbances of frequency = 100 HZ and wavelength to chord ratio of 0.001. Calculations are started at station NSTART = 2. However, if it is felt that the disturbances of the given frequency and wavelength would become unstable further downstream, a larger value of NSTART can be chosen.

Two startup options are available. First option is that the program use an internally computed critical cross flow angle together with user input wavelength to chord ratio to search for the initial instability. Second option is for the user to

specify a discrete set of angles that should be used instead of the critical angle. This case illustrates use of the second option. The inputs are:

ITRIV	=	5
ITYP	=	0
NSTART	=	2
NSTOP	=	20
RFREQ	=	100.
IPSI	=	1
XLENC	=	.001
NPSI	=	4
PSI	=	80., 82., 84., 86.

At NSTART = 2, each user supplied angle is checked for instability in that direction, with none being found for any of the angles. The search procedure continues until an unstable mode is finally detected at station No. 5 at an angle of 80 degrees. COSAL then iterates to the desired frequency of 100 HZ. Note also that for XLENC = .001, the angle corresponding to 100 HZ is PSI = 82.55 so that the orientation angle has been changed almost 2.5° in iterating on the input frequency.

The user is referred to Section 2.3 for complete printout definition.

Case No. 5

This run is the same as Case No. 4 except that it illustrates startup procedure using internally computed critical angle as the search orientation angle. The inputs are:

ITRIV	= 5
ITYP	= 0
NSTART	= 2
NSTOP	= 20
RFREQ	= 100.
IPSI	= 0
XLENC	= .001

Except for starting procedure, the results for Case No. 5 should be the same as those of Case No. 4 starting at station No. 5.

Case No. 6

The purpose of this run is to compute crossflow disturbances of 0.5 HZ with amplification maximization at each station (Envelope method). The user does not specify an orientation or wavelength (except for startup) to be followed along the wing. The program at each station along the wing picks that combination of orientation angle and wavelength that maximizes the amplification rate (imaginary part of OMEGA). The user does, however, have to specify orientation, and/or wavelength information for initial program startup. The inputs for this run are:

ITRIV = 1

ITYP = 0

NSTART = 2

NSTOP = 42

RFREQ = 0.5

XLENC = .0003

IPSI = 0

ITRIV = 1 computation is more prone to jump the track, so as a result, default printout for this option is more extensive than for other ITRIV options.

Case No. 7

The purpose of this run is to compute the amplification of two-dimensional, Tollmien-Schlichting type disturbances with frequency = 5000 HZ at PSI = 0 degrees. The inputs are:

ITRIV = 6

ITYP = 1

NSTART = 15

NSTOP = 42

RFREQ = 5000.

XLENC = .002

IPSI = 0

ICON = 0

Notice that ICON = 0 was selected, and the program will terminate upon encountering a stable region. Note also that only one value of XLENC is input as a guess, although a number of values could have been input.

It should be emphasized here, that when comparing N FACTORS for different frequencies, the user should be careful that the program is picking up the instability as soon as it physically occurs. It is possible for example, for XLENC values input by the user to be off the mark far enough so that COSAL fails to pick up the instability until further downstream, resulting in an N FACTOR that is artificially low. This applies to both ITRIV = 6 and ITRIV = 1.

Case No. 8

This run computes the amplification of two-dimensional type disturbances using the envelope method for frequency = 5000 Hz. The inputs are:

ITRIV	= 1
ITYP	= 1
NSTART	= 15
NSTOP	= 42
RFREQ	= 5000.
XLENC	= .002
IPSI	= 0
ICON	= 0

Case No. 9

This illustrates the restart option available with the ITRIV = 1 envelope method. Case No. 6 which computed amplification of cross-flow disturbances is restarted at station No. 23.

The restart option should be initiated at a station at which good convergence was achieved on an unstable mode.

The inputs for this run are:

ITRIV	= 1
ITYP	= 0
NSTART	= 23
NSTOP	= 42
RFREQ	= 0.5
IBLIND	= 0
IPSI	= 0
ICON	= 0
NR	= 1
ALPHA	= -.3722
BETA	= .7047
REYIN	= .4374175 E + 04
RADIN	= .3755056 E + 05
DSTZIN	= .2623616 E - 02
XNIN	= .255

2.5 Computer Output of Some Selected Test Cases

This section contains the computer output of some selected test cases. In particular, the output is given for test case No. 1, 2, 3, 4 and 6. Because of space limitations, the output of the remaining test cases is not given. The variables which were actually input have been marked. Default values for the remaining variables were assumed in the calculations.

Printout for Test Case No. 1

```
1$CAFDIN
ONSTART  = 0,
OIBLIND  = 1,
ONSTOP   = 0,
ONINTEG  = 2,
OITYP    = 0,
OIBEGIN  = 0,
ONR      = 2,
ONWANT   = 10,
ONSTAT   = 0,
OITRIV   = 0,
ORFREQ   = .5E+00,
OALPHA   = .18E+00,
OBETA    = -.37E+00,
OIAB     = 0,
ONAB     = 0,
OALPX    = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OBETX    = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OIPR1    = 0,
OIPR2    = 1,
OIPR3    = 0,
OIPR4    = 1,
OIPR5    = 0,
OIPR7    = 0,
ONZERO   = 2,
OREYIN   = 0.0,
ORADIN   = 0.0,
ODSTZIN  = 0.0,
OXNIN    = 0.0,
OICON    = 1,
OIPSI    = 0,
OPSI     = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OXLENC   = .5E-03, 0.0, 0.0, 0.0, 0.0,
ONPSI    = 1,
ONXLEN   = 1,
OMG      = 4,
ONG      = 21,
OM       = 5,
ONCHEB   = 21,
OICHEB   = 2,
OIPRZ    = 10,
OYEDGE   = .1E+03,
O$END
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
  YERZ AIRFOIL UPPER SURFACE-------SUCTION  U244
  CHORD =  8.000 FT
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FOR:

ALPHA= .18000 BETA= -.37000

1	-21.81060969	.9176753179
2	21.80100821	.9176668680
3	-17.82498547	.6096703306
4	17.80903779	.6096773590
5	-14.83029096	.4205671392
6	14.80996325	.4205798915
7	-12.39858761	.2932490704
8	12.37528195	.2932589858
9	-10.35985852	.2044633497
10	10.33537868	.2044633733
11	-8.623283047	.1416862717
12	8.599561466	.1416710682
13	-7.132544781	.9718643295E-01
14	7.111777990	.9715482757E-01
15	5.833919394	.6575019520E-01
16	-5.849336051	.6580252919E-01
17	4.738107159	.4382695209E-01
18	-4.745808133	.4389469316E-01
19	3.802462102	.2875044267E-01
20	-3.800564201	.2882631711E-01
21	-2.996279831	.1864768171E-01
22	3.008577389	.1857354323E-01
23	-2.318228892	.1191380095E-01
24	2.340261792	.1185026344E-01
25	-1.753556652	.7568057783E-02
26	1.783493410	.7520194448E-02
27	-1.291155270	.4865119223E-02
28	-.4884671205E-02	1.353989521
29	1.327140958	.4838198861E-02
30	.9647833431	.3315714501E-02
31	-.9228147361	.3349075662E-02
32	-.4877723067E-02	.9724684050
33	-.8184840363E-02	.8702631398
34	.6955263931	.2594051526E-02
35	-.6501789165	.2823423112E-02
36	-.8131242261E-02	.6250183501
37	.5230258788	.2436684633E-02
38	-.1039388056E-01	.5845607510
39	-.4863124390	.2644666126E-02
40	.4701035856	.1332709936E-02
41	-.4172315584	.7519208561E-03
42	.3903758395	.3268405917E-03
43	-.1025979842E-01	.4196842670
44	-.3290073508	.3252745364E-03
45	-.1173156191E-01	.3980350422
46	-.1147070695E-01	.2856012619
47	-.1218790244E-01	.2713298210
48	.1805334060	.2571936080E-03
49	-.1175164000E-01	.1945253924
50	-.1191194134	.2571915688E-03
51	-.1167830507E-01	.1837814318
52	-.1101282122E-01	.1315917547
53	-.1010874613E-01	.1229228238
54	-.9148367547E-02	.8778854919E-01
55	-.7465241238E-02	.8050696324E-01
56	-.6132326427E-02	.5712461549E-01
57	-.3959975615E-02	.5069272521E-01
58	-.2339080816E-02	.3536206827E-01
59	-.9514040229E-02	.8467533270E-02
60	.5087934356E-02	-.4459360185E-02
61	-.2292268061E-03	.2905009255E-01
62	-.5119449594E-03	.2294676217E-01
63	.4160747873E-02	.1786767544E-01
64	.7325189258E-02	.1863447485E-01
65	.1602608747E-01	.1123199849E-01
66	.1735885662E-01	.1294107762E-01
67	.2521824385E-01	.6168309979E-02
68	.2595039544E-01	.7662595160E-02
69	.2949061738E-01	.3875761331E-02
70	.2953755495E-01	.3027290525E-02
71	.3045179816E-01	.1627189345E-02
72	.3050542268E-01	.1197594930E-02
73	.3066303954E-01	.7264220357E-03
74	.3070547793E-01	.2769239856E-03
75	.3067778501E-01	.4719526822E-03
76	.3070138958E-01	.4368842604E-03
77	.3070645336E-01	.3683283908E-03

$$EIGENFUNCTION PRINTED. THE ORDER OF PRINT IS :

J,Y(J),U(J),V(J),P(J),T(J) AND W(J) . NOTE THAT U,V,P,T AND
W ARE COMPLEX.$$

1	100.0	-.4446E-08	.3214E-07	-.7322E-07	-.9827E-08	.9466E-06	-.2862E-05	-.4595E-09	.1556E-08	.9140E-08	-.6606E-07
2	35.74	.2529E-07	.9367E-07	-.5355E-05	-.7407E-06	.4228E-09	.1400E-07	.2554E-09	.4765E-08	-.5198E-07	-.1926E-06
3	21.32	.4399E-06	-.3841E-05	.1925E-04	.2579E-05	.2233E-06	-.5308E-06	.6192E-07	-.1827E-06	-.9042E-06	.7895E-05
4	14.96	-.1858E-04	.1550E-03	-.4222E-03	-.5080E-04	-.6252E-05	.2175E-04	-.2176E-05	.7406E-05	.3819E-04	-.3187E-03
5	11.37	-.1024E-03	.8591E-03	-.2103E-02	-.2503E-03	-.3549E-04	.1204E-03	-.1214E-04	.4103E-04	.2105E-03	-.1766E-02
6	9.076	-.2757E-03	.2323E-02	-.5499E-02	-.6507E-03	-.9624E-04	.3255E-03	-.3284E-04	.1109E-03	.5667E-03	-.4774E-02
7	7.477	-.5390E-03	.4553E-02	-.1062E-01	-.1252E-02	-.1887E-03	.6380E-03	-.6402E-04	.2176E-03	.1108E-02	-.9359E-02
8	6.299	-.8768E-03	.7433E-02	-.1720E-01	-.2022E-02	-.3079E-03	.1042E-02	-.9734E-04	.3503E-03	.1800E-02	-.1526E-01
9	5.396	-.1257E-02	.1079E-01	-.2488E-01	-.2905E-02	-.4472E-03	.1514E-02	-.7430E-04	.4251E-03	.2543E-02	-.2214E-01
10	4.682	-.1803E-02	.1430E-01	-.3321E-01	-.3803E-02	-.5998E-03	.2030E-02	.4685E-03	.4195E-05	.2936E-02	-.2900E-01
11	4.103	-.4975E-02	.1829E-01	-.4149E-01	-.4566E-02	-.7592E-03	.2566E-02	.3383E-02	-.3295E-02	.1348E-02	-.3273E-01
12	3.623	-.1831E-01	.3300E-01	-.4862E-01	-.5102E-02	-.9199E-03	.3087E-02	.9508E-02	-.1759E-01	-.5429E-02	-.2343E-01
13	3.220	-.3534E-01	.9215E-01	-.5335E-01	-.5606E-02	-.1073E-02	.3553E-02	.9262E-02	-.5336E-01	-.1194E-01	.1892E-01
14	2.977	-.2328E-02	.2200	-.5490E-01	-.6622E-02	-.1214E-02	.3930E-02	-.1681E-01	-.1065	.1077E-01	.1045
15	2.580	.1433	.3693	-.5345E-01	-.8666E-02	-.1339E-02	.4199E-02	-.7663E-01	-.1528	.9305E-01	.2035
16	2.322	.3894	.4491	-.4995E-01	-.1176E-01	-.1442E-02	.4361E-02	-.1547	-.1690	.2251	.2649
17	2.094	.6534	.4143	-.4544E-01	-.1540E-01	-.1520E-02	.4434E-02	-.2242	-.1515	.3618	.2639
18	1.893	.8569	.2916	-.4066E-01	-.1893E-01	-.1572E-02	.4442E-02	-.2676	-.1134	.4621	.2139
19	1.713	.9692	.1381	-.3598E-01	-.2184E-01	-.1599E-02	.4410E-02	-.2823	-.7124E-01	.5111	.1446
20	1.552	1.000	0.	-.3155E-01	-.2385E-01	-.1604E-02	.4355E-02	-.2746	-.3575E-01	.5151	.6029E-01
21	1.406	.9752	-.1008	-.2741E-01	-.2493E-01	-.1594E-02	.4292E-02	-.2531	-.1088E-01	.4387	.3251E-01
22	1.274	.9194	-.1616	-.2358E-01	-.2514E-01	-.1572E-02	.4228E-02	-.2252	.3915E-02	.4456	.3055E-02
23	1.153	.8498	-.1893	-.2008E-01	-.2462E-01	-.1543E-02	.4169E-02	-.1955	.1108E-01	.3958	-.1132E-01
24	1.043	.7766	-.1936	-.1691E-01	-.2352E-01	-.1512E-02	.4118E-02	-.1670	.1326E-01	.3451	-.1533E-01
25	.9417	.7048	-.1833	-.1407E-01	-.2199E-01	-.1480E-02	.4074E-02	-.1407	.1262E-01	.2965	-.1326E-01
26	.8484	.6365	-.1652	-.1156E-01	-.2015E-01	-.1451E-02	.4039E-02	-.1173	.1066E-01	.2516	-.8417E-02
27	.7620	.5724	-.1442	-.9372E-02	-.1812E-01	-.1424E-02	.4010E-02	-.9678E-01	.8302E-02	.2109	-.2902E-02
28	.6819	.5125	-.1230	-.7483E-02	-.1600E-01	-.1401E-02	.3988E-02	-.7907E-01	.6053E-02	.1746	.1999E-02
29	.6074	.4566	-.1033	-.5877E-02	-.1387E-01	-.1381E-02	.3972E-02	-.6391E-01	.4139E-02	.1425	.5676E-02
30	.5380	.4045	-.8589E-01	-.4532E-02	-.1178E-01	-.1364E-02	.3961E-02	-.5106E-01	.2624E-02	.1144	.7961E-02
31	.4731	.3558	-.7092E-01	-.3422E-02	-.9797E-02	-.1350E-02	.3953E-02	-.4025E-01	.1469E-02	.9026E-01	.8939E-02
32	.4123	.3102	-.5829E-01	-.2522E-02	-.7952E-02	-.1339E-02	.3949E-02	-.3122E-01	.6752E-03	.6968E-01	.8846E-02
33	.3552	.2676	-.4769E-01	-.1806E-02	-.6273E-02	-.1330E-02	.3948E-02	-.2376E-01	.1164E-03	.5243E-01	.7974E-02
34	.3016	.2277	-.3976E-01	-.1247E-02	-.4780E-02	-.1323E-02	.3949E-02	-.1764E-01	-.2474E-03	.3820E-01	.6620E-02
35	.2510	.1900	-.3116E-01	-.8232E-03	-.3486E-02	-.1318E-02	.3951E-02	-.1269E-01	-.4642E-03	.2670E-01	.5052E-02
36	.2033	.1545	-.2456E-01	-.5112E-03	-.2398E-02	-.1313E-02	.3956E-02	-.8749E-02	-.5691E-03	.1766E-01	.3491E-02
37	.1582	.1208	-.1872E-01	-.2911E-03	-.1516E-02	-.1310E-02	.3961E-02	-.5675E-02	-.5858E-03	.1078E-01	.2109E-02
38	.1155	.8873E-01	-.1344E-01	-.1449E-03	-.8412E-03	-.1307E-02	.3968E-02	-.3355E-02	-.5293E-03	.5803E-02	.1021E-02
39	.7500E-01	.5802E-01	-.8603E-02	-.5643E-04	-.3679E-03	-.1305E-02	.3975E-02	-.1689E-02	-.4090E-03	.2491E-02	.2953E-03
40	.3655E-01	.2850E-01	-.4130E-02	-.1208E-04	-.9006E-04	-.1303E-02	.3983E-02	-.5933E-03	-.2308E-03	.6215E-03	-.4159E-04

41 0. 0. 0. 0. 0. -.1303E-02 .3983E-02 0. 0. 0. 0.

SIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER 10 X/C = .021169 21 NODE POINTS USED

REY = 651.7617 MACH NO. = .923

ALPHA= .18000000 BETA= -.37000000 OMEGA = -.4911333258167E-02 .4416881615197E-02

GROUP VELOCITY COMPUTED

VA = .6810158031455E+00 -.2200531957932E-01 VB = .3590469668763E+00 -.1667405652311E-01

Printout for Test Case No. 2

1

```
1SCARDIN
ONSTART  = 0,
OIRLIND  = 1,
ONSTOP   = 0,
ONINTEG  = 2,
OITYP    = 0,
OIREGIN  = 0,
ONP      = 2,
ONWANT   = 10,
ONSTAT   = 0,
OITPIV   = 0,
ORFREQ   = .5E+00,
OALPHA   = 0.0,
OBETA    = 0.0,
OIAB     = 1,
ONAB     = 2,
OALPY    = .18E+00, .2E+00, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OBETY    = -.37E+00, -.35E+00, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OIPR1    = 0,
OIPR2    = 1,
OIPR3    = 0,
OIPR4    = 0,
OIPR5    = 0,
OIPR7    = 0,
ONZERO   = 2,
ORFYIN   = 0.0,
ORADIN   = 0.0,
ODSTZIN  = 0.0,
OXMIN    = 0.0,
OICON    = 1,
OIPSI    = 0,
OPSI     = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OXLENC   = .5E-03, 0.0, 0.0, 0.0, 0.0,
ONPSI    = 1,
ONXLEN   = 1,
OMG      = 5,
ONG      = 21,
OM       = 5,
ONCHEB   = 21,
OICHEB   = 2,
OIPRZ    = 20,
OYEDGE   = .1E+03,
OSEND
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
  YERZ AIRFOIL UPPER SURFACE-------SUCTION  U244
  CHORD =   8.000 FT
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

ORIGINAL PAGE IS
OF POOR QUALITY

NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FOR:

ALPHA= .18000 BETA= -.37000

1	-21.81061111	.9176379430	49	-.1150827031E-01	.2853794564
2	21.80100963	.9176294744	50	-.1171688120E-01	.2868946459
3	-17.82498969	.6095873433	51	-.1217755035E-01	.2714393461
4	17.80904201	.6095942950	52	.1805334060	.2571934613E-03
5	14.80986814	.4204739676	53	-.1191194134	.2571912706E-03
6	-14.83029574	.4204612995	54	-.1180514185E-01	.1942713245
7	12.37528677	.2931418980	55	-.1213276817E-01	.1957368241
8	-12.39859242	.2931320336	56	-.1168342344E-01	.1839548505
9	10.33538314	.2043427256	57	-.1108153141E-01	.1313311009
10	-10.35986298	.2043426760	58	-.1158868990E-01	.1326654272
11	8.599565495	.1415523967	59	-.1013185577E-01	.1231511901
12	-8.623287070	.1415674473	60	-.9220701952E-02	.8754512913E-01
13	7.111781597	.9704234071E-01	61	-.1001137209E-01	.8869836913E-01
14	-7.132548375	.9707561385E-01	62	-.7510250663E-02	.8076652365E-01
15	-5.840339274	.6569879055E-01	63	-.7442932307E-02	.5781447703E-01
16	5.833922607	.6564700891E-01	64	-.6178817907E-02	.5691275027E-01
17	-4.745911054	.4380207101E-01	65	-.4039149007E-02	.5059915091E-01
18	4.738110091	.4373510503E-01	66	-.4210463399E-02	.3571118641E-01
19	-3.900566926	.2874581372E-01	67	-.2316977872E-02	.3518160859E-01
20	3.802464806	.2867086928E-01	68	-.1046842028E-01	.6591604653E-02
21	-2.996282424	.1857937700E-01	69	-.9575022745E-02	.8564821706E-02
22	3.008579948	.1850617690E-01	70	.5098627381E-02	-.4400388348E-02
23	2.340264260	.1179438779E-01	71	-.3404627437E-03	.2930502988E-01
24	-2.318231402	.1195716055E-01	72	-.5243385906E-03	.2301108158E-01
25	1.783495803	.7474943434E-02	73	-.1863847345E-02	.1918008771E-01
26	-1.758559080	.7522407777E-02	74	.4100078346E-02	.1796737591E-01
27	1.327143228	.4802888708E-02	75	.5624885693E-02	.1477614392E-01
28	-.4883922698E-02	1.354146359	76	.7415485246E-02	.1860918501E-01
29	-1.291157539	.4830105251E-02	77	.1602546411E-01	.1126881099E-01
30	-.9278166693	.3324513575E-02	78	.1736104577E-01	.1291539197E-01
31	.9647853287	.3290066040E-02	79	.1808020643E-01	.9651069396E-02
32	-.4983265010E-02	.9724186144	80	.2521917311E-01	.6170308876E-02
33	-.4922486038E-02	.9732341871	81	.2595008550E-01	.7661053076E-02
34	-.8180547772E-02	.8704032871	82	.2642065942E-01	.5700090294E-02
35	-.6501800432	.2809952179E-02	83	.2949053086E-01	.3875746287E-02
36	.6951276990	.2578832960E-02	84	.2953769466E-01	.3027169195E-02
37	.5230260688	.2431746383E-02	85	.2974244027E-01	.2942773989E-02
38	-.4843120927	.2644913288E-02	86	.3045179505E-01	.1627169414E-02
39	-.8149101076E-02	.5249123264	87	.3050532582E-01	.1197602643E-02
40	-.8219930800E-02	.6260915075	88	.3051570634E-01	.1209788564E-02

41	-.1038171372E-01	.5846485217	89	.3066303952E-01	.7264212683E-03
42	.4701033342	.1332489920E-02	90	.3067510218E-01	.5296303269E-03
43	-.4172314098	.7533759202E-03	91	.3067778473E-01	.4719539375E-03
44	.3903758378	.3268520143E-03	92	.3070293307E-01	.3153574687E-03
45	-.3290073491	.3252903904E-03	93	.3070653780E-01	.2652383576E-03
46	-.1028350472E-01	.4195160048	94	.3070547793E-01	.2769240243E-03
47	-.1041073030E-01	.4209447635	95	.3070138959E-01	.4368841202E-03
48	-.1171441195E-01	.3991055029	96	.3070645335E-01	.3683283852E-03

SIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER 10 X/C = .021169 21 NODE POINTS USED
REY = 651.7617 MACH NO. = .923

ALPHA= .18000000 BETA= -.37000000 OMEGA = -.4911715338958E-02 .4417609523333E-02

GROUP VELOCITY COMPUTED

VA = .6810761108017E+00 -.2196913904144E-01 VB = .3590840127875E+00 -.1665974035710E-01

NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FOR:

ALPHA= .20000 BETA= -.35000

1	-21.81359223	.9176331164	49	-.2174221904E-01	.2852543062
2	21.79800147	.9176188678	50	-.2184940659E-01	.2867193864
3	-17.83037916	.6095752974	51	-.2440617100E-01	.2712977943
4	17.80357299	.6095883610	52	.1471969504	.2475731872E-03
5	14.80211292	.4204714324	53	-.1485619133	.2475796584E-03
6	-14.83791393	.4204440363	54	-.2425553498E-01	.1941260862
7	12.36528986	.2931414457	55	-.2443061660E-01	.1955352255
8	-12.40838447	.2931112548	56	-.2607020428E-01	.1838445905
9	10.32314522	.2043431579	57	-.2603159069E-01	.1325142050
10	-10.37181281	.2043198239	58	-.2573871598E-01	.1312423167
11	8.585073705	.1415526154	59	-.2664463029E-01	.1232071268
12	-8.637386111	.1415437585	60	-.2605893779E-01	.8767061203E-01
13	7.095028940	.9704131787E-01	61	-.2655235341E-01	.8877807520E-01
14	-7.148774855	.9705212766E-01	62	-.2602787134E-01	.8124797841E-01
15	-5.867629066	.6567630309E-01	63	-.2590664916E-01	.5845570904E-01
16	5.814925917	.6564377390E-01	64	-.2508525353E-01	.5746135338E-01
17	-4.766077951	.4378103557E-01	65	-.2428395676E-01	.5225688537E-01
18	4.716929200	.4372876242E-01	66	-.2420193052E-01	.3735218501E-01
19	-3.822624903	.2872618417E-01	67	-.2279169324E-01	.3634799235E-01
20	3.779219221	.2866068465E-01	68	-.2184831149E-01	.3203023282E-01
21	-3.019879985	.1856038004E-01	69	-.2801720882E-01	.4510944195E-02
22	2.983449498	.1849177871E-01	70	-.2774262986E-01	.5780268127E-02

4

23	2.313447284	.1177610826E-01	71	-.1678988948E-01	-.2675049801E-02
24	-2.343055800	.1183690290E-01	72	-.2201649169E-01	.2234833306E-01
25	1.755139947	.7454453084E-02	73	-.1975161812E-01	.2118300075E-01
26	-1.779283866	.7496836079E-02	74	-.2092298229E-01	.1239750030E-01
27	1.297270398	.4785099446E-02	75	-.2007181328E-01	.1751600998E-01
28	-1.317466581	.4789276081E-02	76	-.1742194054E-01	.1632821248E-01
29	-.7906649116E-02	1.354117954	77	-.1373379050E-01	.1212730847E-01
30	.9333140705	.3290107724E-02	78	-.1192187806E-01	.1217830680E-01
31	-.9491310668	.3241568714E-02	79	-.1231495405E-01	.9394861465E-02
32	-.7956832810E-02	.9724077849	80	-.5228152673E-02	.7488797278E-02
33	-.7979551618E-02	.9731962716	81	-.5732653819E-02	.6224092783E-02
34	-.1375509326E-01	.8703500142	82	-.4731464898E-02	.5612266607E-02
35	.6625919610	.2633702125E-02	83	-.1883742311E-02	.3801319876E-02
36	-.6747900634	.2630006279E-02	84	-.1814349850E-02	.2987077219E-02
37	-.5051654643	.2489233265E-02	85	-.1632292389E-02	.2890583817E-02
38	.4995985627	.2551353508E-02	86	-.9377736045E-03	.1600007335E-02
39	-.1379871332E-01	.6248731162	87	-.8818308574E-03	.1178514565E-02
40	-.1383525979E-01	.6260158917	88	-.8733997790E-03	.1190206605E-02
41	-.1824601795E-01	.5845626374	89	-.7268312275E-03	.7098080506E-03
42	-.4395141064	.9170174787E-03	90	-.7146234904E-03	.5177061182E-03
43	.4320225570	.1300489104E-02	91	-.7117346449E-03	.4611418343E-03
44	.3537631385	.3141754671E-03	92	-.6866566605E-03	.3047480831E-03
45	-.3551521992	.3129414100E-03	93	-.6830179734E-03	.2547960259E-03
46	-.1927103840E-01	.4194349879	94	-.6840915966E-03	.2665629260E-03
47	-.1833604833E-01	.4208197268	95	-.6882254173E-03	.4221389311E-03
48	-.2177511599E-01	.3979853273	96	-.6831040299E-03	.3538244844E-03

SIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER 10 X/C = .021169 21 NODE POINTS USED

REY = 651.7617 MACH NO. = .923

ALPHA= .20000000 BETA= -.35000000 OMEGA = .1693762458479E-01 .2635128545090E-02

GROUP VELOCITY COMPUTED

VA = .7625806260821E+00 -.8714775639578E-01 VB = .3991203791099E+00 -.5571343963043E-01

Printout for Test Case No. 3

```
1$CARDIN
ONSTART  = 0,
OIBLIND  = 1,
ONSTOP   = 0,
ONINTEG  = 2,
OITYP    = 0,
OIBEGIN  = 0,
ONB      = 2,
ONWANT   = 10,
ONSTAT   = 0,
OITRIV   = 0,
ORERFC   = .5E+00,
OALPHA   = 0.0,
OBETA    = 0.0,
OIAB     = 2,
ONAB     = 0,
OALPX    = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OBETX    = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OIPR1    = 0,
OIPR2    = 1,
OIPR3    = 0,
OIPR4    = 0,
OIPR5    = 0,
OIPR7    = 0,
ONZERO   = 2,
OREYIN   = 0.0,
ORADIN   = 0.0,
ORSTZIN  = 0.0,
OXNIN    = 0.0,
OICON    = 1,
OIPSI    = 0,
OPSI     = .85E+02, .87E+02, .89E+02, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OXLENC   = .65E-03, 0.0, 0.0, 0.0, 0.0,
ONPSI    = 3,
ONXLEN   = 1,
OMG      = 4,
ONG      = 11,
OM       = 5,
ONCHEB   = 101,
OICHEB   = 2,
OIPRZ    = 0,
OYEDGE   = .1E+03,
O$END
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
  YERZ AIRFOIL UPPER SURFACE-------SUCTION  U244
  CHORD =  8.000 FT
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FOR:

ALPHA= -.20413 BETA= .44461

1	9.219523317	.1623182579	20	-.2483565089	.3881155746E-03
2	-9.206259810	.1623156660	21	.1502177016	.3873113422E-03
3	6.421627247	.7946968170E-01	22	.6404564174E-02	.1708653956
4	-6.403060502	.7946123538E-01	23	.9725706466E-02	.1091476653
5	4.490272649	.3963779431E-01	24	.8322354729E-02	.7727353938E-01
6	-4.473902725	.3959582290E-01	25	.8609553494E-02	.5051306605E-01
7	-3.067446975	.1931387051E-01	26	.5535976915E-02	.3540598700E-01
8	3.072496817	.1940038616E-01	27	.4206065602E-02	.9623107966E-02
9	-2.039963164	.9236217390E-02	28	.3817194867E-02	.1958762349E-01
10	2.025056159	.9356669613E-02	29	-.5727304483E-02	.1893023491E-01
11	1.270495940	.4759092962E-02	30	-.1717843284E-01	-.4555590691E-02
12	-1.308366425	.4628752699E-02	31	-.1966355393E-01	.8345696753E-02
13	.7568397071	.3321804567E-02	32	-.2179875932E-01	.7998740096E-02
14	-.8252955222	.2986927314E-02	33	-.4374091301E-01	.1551323547E-02
15	.5331200356	.2542596273E-02	34	-.4466937232E-01	.2601765725E-02
16	-.5335220860	.2881334107E-02	35	-.4901587201E-01	.9231110876E-03
17	-.5232844685	.2955367300E-03	36	-.4904052667E-01	.4715943606E-03
18	.4222305129	.4266305519E-03	37	-.4905509725E-01	.5346732594E-03
19	.6895762998E-02	.2396736414			

SIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER 10 Y/C = .021169 101 NODE POINTS USED

REY = 651.7617 MACH NO. = .923

XLENC = .65000000E-03 PSI = 85.000000 DEGREES

ALPHA= -.20412673 BETA= .44460924 OMEGA = .1518752445743E-01 .4607467288440E-02

GROUP VELOCITY COMPUTED

VA = .6708702790979E+00 -.7911583941046E-02 VB = .3533342663778E+00 -.7315555624208E-02

NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FOR:

ALPHA= -.21952 BETA= .43721

1	9.222837579	.1623180591	20	-.2287517728	.3880712942E-03
2	-9.203050700	.1623153524	21	.1698230869	.3873824038E-03

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3	6.427804742	.7946452491E-01	22	.9984196560E-02	.1707916026
4	-6.396887732	.7946561773E-01	23	.1605406348E-01	.1090383578
5	4.499213469	.3963189951E-01	24	.1502893597E-01	.7709615080E-01
6	-4.464949188	.3960146484E-01	25	.1764639746E-01	.5077989647E-01
7	-3.055772418	.1931896878E-01	26	.1511207292E-01	.3509352207E-01
8	3.084112514	.1939574936E-01	27	.1627010255E-01	.7371316057E-02
9	-2.025790500	.9241010529E-02	28	.1525119723E-01	.2166139951E-01
10	2.039118413	.9352555399E-02	29	.7294015888E-02	.1783762523E-01
11	1.286611303	.4745580951E-02	30	-.3221485325E-02	-.5174511656E-02
12	-1.292180588	.4641104805E-02	31	-.3652586302E-02	.1182569555E-01
13	.7836400804	.3252274401E-02	32	-.4006248326E-02	.6869349568E-02
14	-.8080989698	.3042574306E-02	33	-.2429840383E-01	.1575629040E-02
15	.5493002504	.2509931652E-02	34	-.2521531598E-01	.2592073686E-02
16	-.5675151376	.2906302466E-02	35	-.2941152848E-01	.9222564025E-03
17	-.5033734585	.3114705255E-03	36	-.2943720354E-01	.4714887402E-03
18	.4419576649	.4251380355E-03	37	-.2945182858E-01	.5346552939E-03
19	.1024184751E-01	.2396137286			

. SIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER 10 X/C = .021169 101 NODE POINTS USED

REY = 651.7617 MACH NO. = .923

XLENC = .65000000E-03 PSI = 87.000000 DEGREES

ALPHA= -.21951903 BETA= .43721447 OMEGA = .1975664096934E-02 .4477749824922E-02

GROUP VELOCITY COMPUTED

VA = .7013096762856E+00 .2353996063571E-01 VB = .3661777489123E+00 .1184256812019E-01

NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FOR:

ALPHA= -.23464 BETA= .42929

1	9.226141125	.1623177316	20	-.2091110776	.3880185389E-03
2	-9.199754970	.1623149140	21	.1894642718	.3974426448E-03
3	6.433966856	.7945908703E-01	22	.1354458687E-01	.1706912782
4	-6.390737228	.7946971500E-01	23	.2235039767E-01	.1087876829
5	-4.456022544	.3960680518E-01	24	.2169912288E-01	.7679899884E-01
6	4.508139402	.3962567009E-01	25	.2670657264E-01	.5065488459E-01
7	-3.044122769	.1932384942E-01	26	.2490535469E-01	.3466389433E-01
8	3.095718360	.1939080503E-01	27	.1141929979E-01	-.4464291608E-02
9	2.053176897	.9348297576E-02	28	.2837004291E-01	.6637156190E-02
10	-2.011631104	.9245790718E-02	29	.2667136487E-01	.2283178059E-01
11	1.302732319	.4732653192E-02	30	.2065498823E-01	.1621847647E-01
12	-1.275994018	.4654102222E-02	31	.1108090018E-01	.1383499361E-01

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13	-.7909379365	.3102079604E-02	32	.1371849303E-01	.6600347114E-02
14	.8005240690	.3186786855E-02	33	-.4809698507E-02	.1610437452E-02
15	.5655124900	.2479320777E-02	34	-.5728522298E-02	.2582119250E-02
16	-.5515061986	.2936084624E-02	35	-.9771214416E-02	.9212975163E-03
17	-.4834505560	.3248044964E-03	36	-.9798004696E-02	.4713749546E-03
18	.4517266278	.4233427596E-03	37	-.9812674040E-02	.5346351449E-03
19	.1357221112E-01	.2395229022			

SIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER 10 X/C = .021169 101 NODE POINTS USED

REY = 651.7617 MACH NO. = .923

XLENC = .6500CC00E-03 PSI = 89.000000 DEGREES

ALPHA= -.23464387 BETA= .42928703 OMEGA = -.1188258236228E-01 .3673664031681E-02

GROUP VELOCITY COMPUTED

VA = .7404244745696E+00 .5961675247658E-01 VB = .3852037783014E+00 .3429229394044E-01

1

Printout for Test Case No. 4

```
1$CAPDIN
ONSTART  = 2,
OIBLIND  = 1,
ONSTOP   = 20,
ONINTEG  = 2,
OITYP    = 0,
OIBEGIN  = C,
ONR      = 2,
ONWANT   = 0,
ONSTAT   = 1,
OITRIV   = 5,
ORFREQ   = .1E+03,
OALPHA   = 0.0,
OBETA    = 0.0,
OIAB     = 0,
ONAB     = 0,
OALPX    = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OBETX    = 0.0, 0.0, 0.C, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OIPR1    = 0,
OIPR2    = C,
OIPR3    = 0,
OIPR4    = 0,
OIPR5    = 0,
OIPR7    = C,
ONZERO   = 2,
OREYIN   = 0.0,
ORADIN   = 0.0,
ODSTZIN  = 0.0,
OXNIN    = 0.0,
OICON    = 1,
OIPSI    = 1,
OPSI     = .8E+02, .82E+02, .84E+02, .86E+02, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OXLENC   = .1E-02, 0.0, 0.0, 0.0, 0.0,
ONPSI    = 4,
ONXLEN   = 1,
OMG      = 4,
ONG      = 21,
OM       = 5,
ONCHEB   = 21,
OICHEB   = 2,
OIPRZ    = 10,
OYEDGE   = .1E+03,
OSEND
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
  YERZ AIPFOIL UPPER SURFACE-------SUCTION  U244
  CHORD =  8.000 FT
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .3967079693449E-01 -.2651057509205E-01

ITRIV = 5 OPTION AT STATION        2  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =     80.000000  DEGREES,,, PHI=     80.232136

  FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   2 XLENC=   .10000000E-02 PSI=   80.000 DEGREES


NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .2965468157485E-01 -.2475021542867E-01

ITRIV = 5 OPTION AT STATION        2  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =     82.000000  DEGREES,,, PHI=     80.232136

  FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   2 XLENC=   .10000000E-02 PSI=   82.000 DEGREES


NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .1936522641630E-01 -.2280369896628E-01

ITRIV = 5 OPTION AT STATION        2  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =     84.000000  DEGREES,,, PHI=     80.232136

  FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   2 XLENC=   .10000000E-02 PSI=   84.000 DEGREES
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NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .8712591009092E-02 -.2051203156519E-01

ITRIV = 5 OPTION AT STATION       2  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =     86.000000  DEGREES,,, PHI=    80.232136


  FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   2 XLENC=   .10000000E-02 PSI=   86.000 DEGREES


NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .7391269089212E-02 -.4455331044186E-02

ITRIV = 5 OPTION AT STATION       3  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =     80.000000  DEGREES,,, PHI=    64.256081


  FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   3 XLENC=   .10000000E-02 PSI=   80.000 DEGREES


NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .2124629686798E-02 -.4300928024385E-02

ITRIV = 5 OPTION AT STATION       3  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =     82.000000  DEGREES,,, PHI=    64.256081
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OF POOR QUALITY

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FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   3 XLENC=   .10000000E-02 PSI=   82.000 DEGREES


    NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
    USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

       .2062328973860E-02 -.1926513359448E-01

ITRIV = 5 OPTION AT STATION       3  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    84.000000  DEGREES,,, PHI=    64.256081

FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   3 XLENC=   .10000000E-02 PSI=   84.000 DEGREES


    NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
    USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

       .1547770777874E-01 -.1398847442954E-01

ITRIV = 5 OPTION AT STATION       3  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    86.000000  DEGREES,,, PHI=    64.256081

FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   3 XLENC=   .10000000E-02 PSI=   86.000 DEGREES


    NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
    USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

       .3407541577982E-02 -.6362127295406E-03
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5

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ITRIV = 5 OPTION AT STATION      4  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    80.000000  DEGREES,,, PHI=    51.960599

   FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   4 XLENC=   .10000000E-02 PSI=   80.000 DEGREES


        NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
        USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

          .1785138141957E-01 -.2002256289812E-01
ITRIV = 5 OPTION AT STATION      4  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    82.000000  DEGREES,,, PHI=    51.960599

   FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   4 XLENC=   .10000000E-02 PSI=   82.000 DEGREES


        NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
        USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

          .1068526266844E-01 -.1969913496365E-01
ITRIV = 5 OPTION AT STATION      4  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    84.000000  DEGREES,,, PHI=    51.960599

   FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION   4 XLENC=   .10000000E-02 PSI=   84.000 DEGREES


        NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
        USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :
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6

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.1123730878489E-01 -.9765906190572E-02

ITPIV = 5 OPTION AT STATION      4  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    86.000000  DEGREES,,, PHI=    51.960599


   FOR ITPIV=5 OPTION, NO UNSTABLE MODE AT STATION   4 XLENC=   .10000000E-02 PSI=   86.000 DEGREES


ITRIV = 5 OPTION AT STATION      5  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    80.000000  DEGREES,,, PHI=    43.952894


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1957771808092E-03
          INITIAL STATION NO.       5   X/C=     .003529   RESULTS ARE


 ALPHA=     -.08950874   BETA=      .12093145          OMEGA=       .1957621717527E-03  .4450935145725E-03

   GROUP VELOCITY COMPUTED
        VA =  .6355011645033E+00 -.1812740540037E-01     VB =  .5368518858113E+00  .3783839777288E-01
                  ARG =     .27929503E+01
        XLENC  =   .10000000E-02     PSI=  82.554484      PHI=       43.952894     RFREQ =     .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
 N FACTOR AT INITIAL STATION NO.       5  IS N=    .030
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    6   PREVIOUS RADIUS   .3755173E+05   ORIGINAL REY   .2857648E+03   ORIGINAL DSTZ   .2181893E-03
LOCAL MACH NO. =    .625
STATION NO    6   NEW RADIUS   .3755171E+05   NEW REY   .2857647E+03   NEW DSTZ   .2181892E-03
 DP=  -.2015333E-01   DS=   .3122971E-01


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1866796144713E-03

 ALPHA=     -.09338092   BETA=      .14368735          OMEGA=       .1866779925617E-03  .9450873869457E-03

   GROUP VELOCITY COMPUTED
        VA =  .6554254049437E+00 -.8732495153257E-02     VB =  .4737979315470E+00  .3192554282158E-01
                  ARG =     .53558401E+01
        XLENC  =   .10000000E-02     PSI=  84.111818      PHI=       38.907583     RFREQ =     .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    6   X/C =   .0058045   IS N =   .158
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    7   PREVIOUS RADIUS   .3755171E+05   ORIGINAL REY   .3645321E+03   ORIGINAL DSTZ   .2551469E-03
LOCAL MACH NO. =    .718
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STATION NO    7   NEW RADIUS   .3755169E+05   NEW REY   .3645319E+03   NEW DSTZ   .2551468E-03
 DR=  -.1921257E-01   DS=   .3279469E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1923344859743E-03

  ALPHA=     -.10177567   BETA=     .17262250          OMEGA=      .1923341452303E-03  .1546007825600E-02

    GROUP VELOCITY COMPUTED
         VA =  .6609809965826E+00  .2599605383568E-02     VB =  .4268232148944E+00  .3112758395200E-01
                    APG =     .77010565E+01
         XLENC =   .10000000E-02     PSI=  85.105776      PHI=       35.417176     RFREQ =     .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    7   X/C =    .0086999   IS N =   .372
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    8   PREVIOUS RADIUS   .3755169E+05   ORIGINAL REY   .4506319E+03   ORIGINAL DSTZ   .2981838E-03
LOCAL MACH NO. =    .796
STATION NO    8   NEW RADIUS    .3755167E+05   NEW REY   .4506315E+03   NEW DSTZ   .2981835E-03
 DR=  -.1907519E-01   DS=   .3516352E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .2047697748203E-03

  ALPHA=     -.11280595   BETA=     .20523399          OMEGA=      .2047690157227E-03  .2170885885383E-02

    GROUP VELOCITY COMPUTED
         VA =  .6674897049625E+00  .1585456472846E-01     VB =  .3966896919588E+00  .3235041217049E-01
                    APG =     .93762421E+01
         XLENC =   .10000000E-02     PSI=  85.859224      PHI=       32.935956     RFREQ =     .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    8   X/C =    .0122222   IS N =   .672
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    9   PREVIOUS RADIUS   .3755167E+05   ORIGINAL REY   .5458312E+03   ORIGINAL DSTZ   .3479557E-03
LOCAL MACH NO. =    .863
STATION NO    9   NEW RADIUS    .3755165E+05   NEW REY   .5458306E+03   NEW DSTZ   .3479554E-03
 DR=  -.1944418E-01   DS=   .3805954E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .2225074196042E-03

  ALPHA=     -.12624730   BETA=     .24237442          OMEGA=      .2225073937947E-03  .2789782832140E-02

    GROUP VELOCITY COMPUTED
         VA =  .6725946451478E+00  .2579150217908E-01     VB =  .3747167972700E+00  .3266601437315E-01
                    APG =     .10413436E+02
         XLENC =   .10000000E-02     PSI=  86.413775      PHI=       31.100183     RFREQ =     .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION  ) 9   X/C =    .0163775   IS N =  1.049
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$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   10   PREVIOUS RADIUS   .3755165E+05   ORIGINAL REY   .6517617E+03   ORIGINAL DSTZ   .4048891E-03
LOCAL MACH NO. =   .923
STATION NO   10   NEW RADIUS   .3755163E+05   NEW REY   .6517609E+03   NEW DSTZ   .4048886E-03
 DP=  -.2009057E-01   DS=   .4128025E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .2444227437784E-03

  ALPHA=     -.14180901   BETA=      .28462826          OMEGA=       .2440447915952E-03  .3405954365627E-02

    GROUP VELOCITY COMPUTED
         VA =  .6768C02849945E+00  .3597817909129E-01     VB =  .3572961018442E+00  .3240773910049E-01
                   ARG =     .10991541E+02
         XLENC =   .10000000E-02      PSI=  86.823087       PHI=       29.660542      RFREO =       .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   10    X/C =    .0211690    IS N =  1.490
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   11   PREVIOUS RADIUS   .3755163E+05   ORIGINAL REY   .7743292E+03   ORIGINAL DSTZ   .4727018E-03
LOCAL MACH NO. =   .975
STATION NO   11   NEW RADIUS   .3755161E+05   NEW REY   .7743279E+03   NEW DSTZ   .4727011E-03
 DP=  -.2087060E-01   DS=   .4470457E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .2724997410594E-03

  ALPHA=     -.16086897   BETA=      .33459506          OMEGA=       .2723035962134E-03  .4075832548051E-02

    GROUP VELOCITY COMPUTED
         VA =  .6799334899383E+00  .4449551784211E-01     VB =  .3434198783513E+00  .3219562269178E-01
                   ARG =     .11319399E+02
         XLENC =   .10000000E-02      PSI=  87.139723       PHI=       28.537903      RFREQ =       .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   11    X/C =    .0266023    IS N =  1.989
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   12   PREVIOUS RADIUS   .3755161E+05   ORIGINAL REY   .1028970E+04   ORIGINAL DSTZ   .6159599E-03
LOCAL MACH NO. =  1.057
STATION NO   12   NEW RADIUS   .3755156E+05   NEW REY   .1028967E+04   NEW DSTZ   .6159586E-03
 DP=  -.4550048E-01   DS=   .1009249E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .3318682040735E-03

  ALPHA=     -.20117245   BETA=      .43996059          OMEGA=       .3318681643149E-03  .4891427667977E-02

    GROUP VELOCITY COMPUTED
         VA =  .6924134979936E+00  .5084435215300E-01     VB =  .3272598469614E+00  .2794899361442E-01
                   ARG =     .10369003E+02
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         XLENC =   .10000000E-02      PSI=  87.630087      PHI=        26.942193      RFREQ =      .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   12   X/C =    .0394226    IS N =  3.084
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   13   PREVIOUS RADIUS   .3755156E+05   ORIGINAL REY   .1303032E+04   ORIGINAL DSTZ   .7745799E-03
LOCAL MACH NO. =  1.105
STATION NO   13   NEW RADIUS   .3755151E+05   NEW REY   .1303028E+04   NEW DSTZ   .7745777E-03
 DR=  -.4998137E-01   DS=   .1169672E+00


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .4028148992728E-03

  ALPHA=     -.24986333   BETA=      .55467079          OMEGA=        .4028145626605E-03  .4888579173401E-02

    GROUP VELOCITY COMPUTED
         VA =  .7098489989535E+00  .5075419921435E-01     VB =  .3254091975190E+00  .2330788549832E-01
                    APG =    .80822496E+01
         XLENC =   .10000000E-02      PSI=  88.118746      PHI=        26.131437      RFREQ =      .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   13   X/C =    .0549125    IS N =  4.163
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   14   PREVIOUS RADIUS   .3755151E+05   ORIGINAL REY   .1765303E+04   ORIGINAL DSTZ   .1047485E-02
LOCAL MACH NO. =  1.121
STATION NO   14   NEW RADIUS   .3755143E+05   NEW REY   .1765296E+04   NEW DSTZ   .1047480E-02
 DR=  -.8685374E-01   DS=   .2084236E+00


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5382587617906E-03

  ALPHA=     -.34306793   BETA=      .74774385          OMEGA=        .5362322788633E-03  .4003560345222E-02

    GROUP VELOCITY COMPUTED
         VA =  .7364353833259E+00  .4931365860835E-01     VB =  .3379717295567E+00  .2082873062833E-01
                    APG =    .47169641E+01
         XLENC =   .10000000E-02      PSI=  88.784659      PHI=        25.861172      RFREQ =      .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   14   X/C =    .0831798    IS N =  5.497
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   15   PREVIOUS RADIUS   .3755143E+05   ORIGINAL REY   .2184070E+04   ORIGINAL DSTZ   .1296816E-02
LOCAL MACH NO. =  1.115
STATION NO   15   NEW RADIUS   .3755132E+05   NEW REY   .2184058E+04   NEW DSTZ   .1296809E-02
 DR=  -.1034660E+00   DS=   .2490610E+00


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .6694400366523E-03

  ALPHA=     -.43364057   BETA=      .92158523          OMEGA=        .6681948124998E-03  .2481733203534E-02
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    GROUP VELOCITY COMPUTED
          VA =  .7678830955321E+00  .2872948791411E-01     VB =  .3592623150960E+00  .1082222846873E-01
                      ARG =    .22573615E+01
          XLENC =    .10000000E-02      PSI=  89.234616      PHI=       25.964117     RFREQ =      .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   15   X/C =   .1171658   IS N =  6.362
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   16   PREVIOUS RADIUS   .3755132E+05   ORIGINAL REY   .2545447E+04   ORIGINAL DSTZ   .1512918E-02
LOCAL MACH NO. =  1.106
STATION NO   16   NEW RADIUS   .3755120E+05   NEW REY   .2545429E+04   NEW DSTZ   .1512907E-02
 DR=  -.1209249E+00   DS=   .2853552E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .7861438670482E-03

  ALPHA=     -.51346744    BETA=     1.07156418          OMEGA=       .7863173411891E-03  .1063285007451E-02

    GROUP VELOCITY COMPUTED
          VA =  .7932544924764E+00  .2710623667128E-02     VB =  .3778948334219E+00 -.2115974084729E-02
                      ARG =    .79985767E+00
          XLENC =    .10000000E-02      PSI=  89.490277      PHI=       26.112309     RFREQ =      .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   16   X/C =   .1563292   IS N =  6.798
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   17   PREVIOUS RADIUS   .3755120E+05   ORIGINAL REY   .2850489E+04   ORIGINAL DSTZ   .1695941E-02
LOCAL MACH NO. =  1.097
STATION NO   17   NEW RADIUS   .3755107E+05   NEW REY   .2850464E+04   NEW DSTZ   .1695926E-02
 DR=  -.1371249E+00   DS=   .3188411E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .8866174939745E-03

  ALPHA=     -.58171322    BETA=     1.19823652          OMEGA=       .8867758402132E-03  .1033832559274E-03

    GROUP VELOCITY COMPUTED
          VA =  .8120940610687E+00 -.1764503575150E-01     VB =  .3923002847451E+00 -.1199166878858E-01
                      ARG =    .67591505E-01
          XLENC =    .10000000E-02      PSI=  89.645537      PHI=       26.249832     RFREQ =      .10000000E+03  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   17   X/C =   .2000761   IS N =  6.936
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   18   PREVIOUS RADIUS   .3755107E+05   ORIGINAL REY   .3126947E+04   ORIGINAL DSTZ   .1861922E-02
LOCAL MACH NO. =  1.091
STATION NO   18   NEW RADIUS   .3755092E+05   NEW REY   .3126913E+04   NEW DSTZ   .1861902E-02
 DR=  -.1513327E+00   DS=   .3479122E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .9778197175072E-03
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NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .1636547924900E-02 -.3809996319504E-03

ALPHA=     -.64320749   BETA=     1.31327943        OMEGA=      .9784592743005E-03 -.4844067786315E-03

GROUP VELOCITY COMPUTED
   VA =  .8271131502452E+00 -.3121065568619E-01     VB =  .4035224766422E+00 -.1835724781085E-01

$$$ STABLE REGION ENCOUNTERED--ICON =     1  WAS SELECTED----PROGRAM CONTINUES$$$

NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .7000646554137E-03 -.6893901893309E-03

ITRIV = 5 OPTION AT STATION      19  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    89.827521  DEGREES,,, PHI=    26.448557

FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION  19 XLENC=   .10000000E-02 PSI=   89.829 DEGREES

NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .1150354729370E-02 -.8971279412515E-03

ITRIV = 5 OPTION AT STATION      20  LOOKING FOR    UNSTABLE MODE FOR XLENC =     .10000000E-02
PSI =    89.878991  DEGREES,,, PHI=    26.548857

FOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION  20 XLENC=   .10000000E-02 PSI=   89.879 DEGREES
```

Printout for Test Case No. 6


```
1SCARDIN
ONSTART   = 2,
OIBLIND   = 1,
ONSTOP    = 42,
ONINTEG   = 2,
OITYP     = 0,
OIBEGIN   = 0,
ONR       = 2,
ONWANT    = 0,
ONSTAT    = 1,
OITRIV    = 1,
OPFREQ    = .5E+00,
OALPHA    = 0.0,
OBETA     = 0.0,
OIAB      = 0,
ONAB      = 0,
OALPX     = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OBETX     = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OIPR1     = 0,
OIPR2     = 0,
OIPR3     = 0,
OIPR4     = 0,
OIPR5     = 0,
OIPR7     = 0,
ONZERO    = 2,
OBEYIN    = 0.0,
ORADIN    = 0.0,
ODSTZIN   = 0.0,
OXNIN     = 0.0,
OICON     = 1,
OIPSI     = 0,
OPSI      = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
OXLENC    = .3E-03, 0.0, 0.0, 0.0, 0.0,
ONPSI     = 1,
ONXLEN    = 1,
OMG       = 4,
ONG       = 21,
OM        = 5,
ONCHEB    = 21,
OICHEB    = 2,
OIPRZ     = 10,
OYEDGE    = .1E+03,
O$END
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
  YERZ AIRFOIL UPPER SURFACE-------SUCTION  U244
  CHORD =  8.000 F"
 $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

   .1345919222572E-01 -.2027113205810E-01

ITRIV=      1  AT STATION     2  LOOKING FOR UNSTABL MODE AT PSI =   87.869217    DEGREES
 XLENC =    .30000000E-03

  ALPHA=     -.36083848   BETA=       .07603151          OMEGA =       .1285193013051E-01 -.2102217037598E-01
 ITRIV=      1  NO INSTABILITY  FOR INPUT     WAVELENGTH RANGE AT STATION      2

ITRIV=      1  AT STATION     3  LOOKING FOR UNSTABL MODE AT PSI =   85.459882    DEGREES
 XLENC =    .30000000E-03

  ALPHA=     -.37060323   BETA=       .21642434          OMEGA =       .4904906045503E-02  .2604517696940E-02

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1801851718073E-05


INITIAL STATION OPTIMIZER LOOP

  ALPHA=     -.37223935   BETA=       .21343730          OMEGA=       .1801672173551E-05  .2416836577388E-02
    GROUP VELOCITY COMPUTED
         VA =  .6946586732396E+00  .3687210687253E-01     VB =  .1266455307162E+01  .4653564857665E-01
  ALPHA=     -.38081912   BETA=       .21814813          OMEGA=       .1801827571479E-05  .2310949206473E-02
    GROUP VELOCITY COMPUTED
         VA =  .6968402881378E+00  .3702107534368E-01     VB =  .1267808476967E+01  .4240206390558E-01


INITIAL STATION OPTIMIZER LOOP

  ALPHA=     -.38081912   BETA=       .21814813          OMEGA=       .1801827571479E-05  .2310949206473E-02
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                                                                                             3

      GROUP VELOCITY COMPUTED
           VA =  .6968402881378E+00  .3702107534368E-01      VB =  .1267808476967E+01  .4240206390558E-01
    ALPHA=      -.33102671    BETA=       .19078015            OMEGA=       -.1967830218961E-03  .2629753682557E-02
      GROUP VELOCITY COMPUTED
           VA =  .6834620900338E+00  .3491972023649E-01      VB =  .1257376844471E+01  .6460157269019E-01


  INITIAL STATION OPTIMIZER LOOP

    ALPHA=      -.33102671    BETA=       .19078015            OMEGA=       -.1967830218961E-03  .2629753682557E-02
      GROUP VELOCITY COMPUTED
           VA =  .6834620900338E+00  .3491972023649E-01      VB =  .1257376844471E+01  .6460157269019E-01
    ALPHA=      -.33166282    BETA=       .19128386            OMEGA=        .1800715358979E-05  .2640122602515E-02
      GROUP VELOCITY COMPUTED
           VA =  .6834188244184E+00  .3487298489648E-01      VB =  .1257218887476E+01  .6406647870569E-01


  INITIAL STATION OPTIMIZER LOOP

    ALPHA=      -.33166282    BETA=       .19128386            OMEGA=        .1800715358979E-05  .2640122602515E-02
      GROUP VELOCITY COMPUTED
           VA =  .6834188244184E+00  .3487298489648E-01      VB =  .1257218887476E+01  .6406647870569E-01
    ALPHA=      -.33152720    BETA=       .19121013            OMEGA=        .1795815646709E-05  .2640095281948E-02
      GROUP VELOCITY COMPUTED
           VA =  .6833785605115E+00  .3486230225492E-01      VB =  .1257179590784E+01  .6411870834396E-01


  END OF INITIAL STATION OPTIMIZER AT STATION        3    X/C =      .000733    FINAL RESULTS ARE
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ALPHA=     -.33149655   BETA=      .19119348          OMEGA=       .1800710450588E-05  .2640088697566E-02

  GROUP VELOCITY COMPUTED
       VA =  .6833694537065E+00  .3485988165344E-01     VB =  .1257170693504E+01  .6413049371851E-01
                     ARG =     .11255096E+02
       XLENC =   .33644394E-03      PSI=  85.769519      PHI=       64.256081      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
 N FACTOR AT INITIAL STATION NO.        3  IS N=     .156
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO     4   PREVIOUS RADIUS    .3755173E+05   ORIGINAL REY    .1571984E+03   ORIGINAL DSTZ    .1754133E-03
LOCAL MACH NO. =    .386
STATION NO     4   NEW RADIUS    .3755169E+05   NEW REY    .1571983E+03   NEW DSTZ    .1754132E-03
 DR=  -.3534143E-01    DS=    .4022527E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .1188320919899E-05


MAIN OPTIMIZER LOOP, NUMB=     1

 ALPHA=     -.31812862   BETA=      .29816462          OMEGA=      -.6024985617869E-03  .6115854189913E-02

  GROUP VELOCITY COMPUTED
       VA =  .6967213816783E+00  .3152860665425E-01     VB =  .7701560852750E+00  .2411389205941E-01


MAIN OPTIMIZER LOOP, NUMB=     2

 ALPHA=     -.30109352   BETA=      .28353768          OMEGA=      -.2824671941086E-04  .6251425290698E-02

  GROUP VELOCITY COMPUTED
       VA =  .6919664522116E+00  .3193792157766E-01     VB =  .7686807076505E+00  .3087523738147E-01


MAIN OPTIMIZER LOOP, NUMB=     3

 ALPHA=     -.28861432   BETA=      .27234220          OMEGA=      -.1308803695025E-04  .6274068050155E-02

  GROUP VELOCITY COMPUTED
       VA =  .6886883099434E+00  .3229937100090E-01     VB =  .7676114767547E+00  .3624879582192E-01
```

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MAIN OPTIMIZER LOOP, NUMB=    4

  ALPHA=      -.28924172   BETA=      .27292368          OMEGA=      .1137105928232E-05  .6274938080799E-02

    GROUP VELOCITY COMPUTED
         VA =  .6888403128547E+00  .3227360924780E-01     VB =  .7676572717639E+00  .3595919457778E-01


MAIN OPTIMIZER LOOP, NUMB=    5

  ALPHA=      -.28922383   BETA=      .27290770          OMEGA=      .1188767109895E-05  .6274936831082E-02

    GROUP VELOCITY COMPUTED
         VA =  .6888354506585E+00  .3227391392821E-01     VB =  .7676554498016E+00  .3596668817426E-01
                   ARG =     .34683206E+02
         XLENC =   .34645437E-03      PSI=  84.701796      PHI=        51.960599      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    4   X/C =    .0018686    IS N =  1.080
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO     5   PREVIOUS RADIUS    .3755169E+05   ORIGINAL REY    .2186851E+03   ORIGINAL DSTZ    .1915634E-03
LOCAL MACH NO. =    .517
STATION NO     5   NEW RADIUS    .3755167E+05    NEW REY    .2186849E+03    NEW DSTZ    .1915632E-03
 DR=  -.2433838E-01   DS=    .3270041E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .9788851261891E-06


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=      -.26139999   BETA=      .32137169          OMEGA=     -.2443371463730E-04  .5859217192377E-02

    GROUP VELOCITY COMPUTED
         VA =  .7061480744110E+00  .2656652066105E-01     VB =  .5974911764778E+00  .2078832063194E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=      -.25798852   BETA=      .31738236          OMEGA=     -.1012786201571E-07  .5864106911119E-02
```

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   GROUP VELOCITY COMPUTED
        VA =  .7052797496390E+00  .2685548709663E-01     VB =  .5973220390753E+00  .2210115235570E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.25590348   BETA=      .31492213          OMEGA=       .6556768417781E-06  .5864483278012E-02

   GROUP VELOCITY COMPUTED
        VA =  .7047583878068E+00  .2703976359371E-01     VB =  .5972200205586E+00  .2292067943964E-01


MAIN OPTIMIZER LOOP, NUMB=    4

  ALPHA=     -.25592528   BETA=      .31494840          OMEGA=       .9778333157518E-06  .5864500337479E-02

   GROUP VELOCITY COMPUTED
        VA =  .7047634502521E+00  .2703741751531E-01     VB =  .5972208046188E+00  .2291156151941E-01
                    ARG =     .33139933E+02
        XLENC =    .37073856E-03      PSI=  85.144046      PHI=        43.952894      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    5   X/C =    .0035293   IS N =  2.189
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    6   PREVIOUS RADIUS   .3755167E+05   ORIGINAL REY   .2857648E+03   ORIGINAL DSTZ   .2181893E-03
LOCAL MACH NO. =   .625
STATION NO    6   NEW RADIUS   .3755165E+05   NEW REY   .2857645E+03   NEW DSTZ   .2181890E-03
 DP=  -.2021620E-01   DS=   .3127029E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .9333973298640E-06


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.23742456   BETA=      .34131571          OMEGA=      -.1939299206950E-05  .4784628378520E-02

   GROUP VELOCITY COMPUTED
        VA =  .7133442601911E+00  .2067057166730E-01     VB =  .5140949092961E+00  .1453669701192E-01
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MAIN OPTIMIZER LOOP, NUMB=     2
  ALPHA=      -.23631218   BETA=       .33977779          OMEGA=       .8827459995249E-06  .4784806502071E-02
    GROUP VELOCITY COMPUTED
         VA =  .7130760514841E+00  .2081383058483E-01     VB =  .5140456269536E+00  .1492782034258E-01

MAIN OPTIMIZER LOOP, NUMB=     3
  ALPHA=      -.23601265   BETA=       .33936238          OMEGA=       .9417195618014E-06  .4784759024082E-02
    GROUP VELOCITY COMPUTED
         VA =  .7130045348216E+00  .2085318791584E-01     VB =  .5140326333948E+00  .1503413245799E-01

MAIN OPTIMIZER LOOP, NUMB=     4
  ALPHA=      -.23601367   BETA=       .33936378          OMEGA=       .9333419442624E-06  .4784758999800E-02
    GROUP VELOCITY COMPUTED
         VA =  .7130047919430E+00  .2085306938495E-01     VB =  .5140326867890E+00  .1503378506505E-01
                   ARG =     .2494872 05E+02
         XLENC =   .41456176E-03      PSI=  85.909283      PHI=       38.907583     PFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    6   X/C =   .0059045   IS N =  3.097
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    7   PREVIOUS RADIUS    .3755165E+05   ORIGINAL REY   .3645321E+03   ORIGINAL DSTZ    .2551469E-03
LOCAL MACH NO. =   .718
STATION NO    7   NEW RADIUS   .3755163E+05    NEW REY    .3645316E+03    NEW DSTZ    .2551466E-03
 DP=  -.1916078E-01   DS=   .3276434E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .9616716655505E-06

MAIN OPTIMIZER LOOP, NUMB=     1
  ALPHA=      -.22702190   BETA=       .36588692          OMEGA=      -.5143393075986E-05  .4385560381394E-02
    GROUP VELOCITY COMPUTED
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VA =  .7107898685567E+00  .1969329598951E-01     VB =  .4555025804781E+00  .1247397906149E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.22639572   BETA=      .36492319          OMEGA=       .9654648336882E-06  .4385663545113E-02

    GROUP VELOCITY COMPUTED
       VA =  .7106334368697E+00  .1978270069036E-01     VB =  .4554718865255E+00  .1266826590551E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.22634422   BETA=      .36484283          OMEGA=       .9645946129987E-06  .4385652110197E-02

    GROUP VELOCITY COMPUTED
       VA =  .7106214642427E+00  .1979110439099E-01     VB =  .4554698931070E+00  .1268515746848E-01
                  ARG =     .20364398E+02
       XLENC =    .46673153E-03      PSI=  86.397631      PHI=        35.417176     RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    7   X/C =     .0086999    IS N =  3.840
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO     8   PREVIOUS RADIUS    .3755163E+05   ORIGINAL REY    .4506319E+03   ORIGINAL DSTZ    .2981838E-03
LOCAL MACH NO. =    .796
STATION NO     8   NEW RADIUS    .3755161E+05    NEW REY    .4506312E+03    NEW DSTZ    .2981833E-03
 DP=  -.1893348E-01   DS=    .3508681E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .1023848062295E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.22290091   BETA=      .39036636          OMEGA=      -.6983124551925E-05  .4262188708447E-02

    GROUP VELOCITY COMPUTED
       VA =  .7102588162244E+00  .2238208879565E-01     VB =  .4175926983734E+00  .1310016433144E-01


MAIN OPTIMIZER LOOP, NUMB=    2
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 ALPHA=     -.22259308   BETA=      .38986198          OMEGA=        .1034294995470E-05  .4262388875449E-02

  GROUP VELOCITY COMPUTED
       VA =  .7101715486565E+00  .2242260105653E-01     VB =  .4175721502584E+00  .1318042436224E-01


MAIN OPTIMIZER LOOP, NUMB=    3

 ALPHA=     -.22257264   BETA=      .38982718          OMEGA=        .1025089863176E-05  .4262383952655E-02

  GROUP VELOCITY COMPUTED
       VA =  .7101668404316E+00  .2242658356542E-01     VB =  .4175713946312E+00  .1318675319322E-01
               ARG =     .17351197E+02
       XLENC =   .52171245E-03      PSI=  86.788168      PHI=       32.935956      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    8    X/C =    .0122222    IS N =  4.501
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    9   PREVIOUS RADIUS    .3755161E+05   ORIGINAL REY   .5458312E+03   ORIGINAL DSTZ   .3479557E-03
LOCAL MACH NO. =    .863
STATION NO    9   NEW RADIUS   .3755159E+05   NEW REY   .5458302E+03   NEW DSTZ   .3479551E-03
 DR=  -.1923769E-01   DS=   .3795442E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1112536218952E-05


MAIN OPTIMIZER LOOP, NUMB=    1

 ALPHA=     -.22156532   BETA=      .41357064          OMEGA=       -.6365084936047E-05  .4278138707210E-02

  GROUP VELOCITY COMPUTED
       VA =  .7086779361140E+00  .2502165135580E-01     VB =  .3900882582773E+00  .1374141569345E-01


MAIN OPTIMIZER LOOP, NUMB=    2

 ALPHA=     -.22137647   BETA=      .41324673          OMEGA=        .1120890647434E-05  .4278367958975E-02

  GROUP VELOCITY COMPUTED
       VA =  .7086172641467E+00  .2504447463262E-01     VB =  .3900720928104E+00  .1378374894267E-01
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MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.22136119   BETA=      .41321895           OMEGA=       .1113487206962E-05  .4278364281258E-02

    GROUP VELOCITY COMPUTED
         VA =  .7086136725043E+00  .2504792407854E-01     VB =  .3900714737219E+00  .1378831675093E-01
                   APG =    .15200915E+02
         XLENC =   .58297185E-03     PSI=  87.077578      PHI=       31.100183     RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    9   X/C =   .0163775   IS N =  5.119
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   10   PREVIOUS RADIUS   .3755159E+05   ORIGINAL REY   .6517617E+03   ORIGINAL DSTZ   .4048891E-03
LOCAL MACH NO. =    .923
STATION NO   10   NEW RADIUS    .3755157E+05   NEW REY   .6517604E+03   NEW DSTZ   .4048883E-03
 DP=  -.1985073E-01   DS=   .4116401E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1222112757144E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.22194855   BETA=      .43649941           OMEGA=      -.6098719915300E-05  .4403092834660E-02

    GROUP VELOCITY COMPUTED
         VA =  .7061236907073E+00  .2857038075150E-01     VB =  .3683044729454E+00  .1488213184192E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.22181549   BETA=      .43626419           OMEGA=       .1228519709809E-05  .4403364643834E-02

    GROUP VELOCITY COMPUTED
         VA =  .7060750244400E+00  .2858369616136E-01     VB =  .3682904484861E+00  .1490721813809E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.22180962   BETA=      .43623565           OMEGA=       .1223048317405E-05  .4403361191117E-02
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GROUP VELOCITY COMPUTED
     VA =  .7060714511296E+00  .2858749131026E-01     VB =  .3682898030780E+00  .1491156944490E-01
               ARG =      .13656669E+02
     XLENC =    .64979240E-03     PSI=  87.289992     PHI=        29.660542     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   10    X/C =    .0211690    IS N =  5.713
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   11   PREVIOUS RADIUS   .3755157E+05   ORIGINAL REY   .7743292E+03   ORIGINAL DSTZ   .4727018E-03
LOCAL MACH NO. =   .975
STATION NO   11   NEW RADIUS   .3755155E+05   NEW REY   .7743273E+03   NEW DSTZ   .4727007E-03
 DR=  -.2062090E-01   DS=   .4458849E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1362497637601E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.22607047   BETA=      .46353087          OMEGA=       -.9176981394829E-05  .4687003461224E-02

   GROUP VELOCITY COMPUTED
     VA =  .7030256858308E+00  .3358506066203E-01     VB =  .3511681378758E+00  .1676654054548E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.22599218   BETA=      .46340414          OMEGA=        .1365910582958E-05  .4687494268491E-02

   GROUP VELOCITY COMPUTED
     VA =  .7029814928818E+00  .3357628404834E-01     VB =  .3511527303599E+00  .1676916388408E-01
               ARG =      .12619412E+02
     XLENC =    .72008757E-03     PSI=  87.459416     PHI=        28.537903     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   11    X/C =    .0266023    IS N =  6.299
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   12   PREVIOUS RADIUS   .3755155E+05   ORIGINAL REY   .1028970E+04   ORIGINAL DSTZ   .6159599E-03
LOCAL MACH NO. =   1.057
STATION NO   12   NEW RADIUS   .3755151E+05   NEW REY   .1028967E+04   NEW DSTZ   .6159581E-03
 DR=  -.4499958E-01   DS=   .1006999E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .1659339731123E-05
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MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.23445237   BETA=      .50951512         OMEGA=      -.2363174120974E-04  .5009163713943E-02

    GROUP VELOCITY COMPUTED
         VA =  .7032583715586E+00  .4194393528732E-01     VB =  .3302948641632E+00  .1970167775791E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.23444061   BETA=      .50956666         OMEGA=       .1657250023549E-05  .5010673605818E-02

    GROUP VELOCITY COMPUTED
         VA =  .7031950316571E+00  .4186501265940E-01     VB =  .3302677801782E+00  .1965570065248E-01
                APG =    .10470916E+02
         XLENC =   .86247621E-03    PSI=  87.763773     PHI=       26.942193     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   12   X/C =    .0394226   IS N =  7.461
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   13   PREVIOUS RADIUS   .3755151E+05   ORIGINAL REY   .1303032E+04   ORIGINAL DSTZ   .7745799E-03
LOCAL MACH NO. =  1.105
STATION NO   13   NEW RADIUS   .3755146E+05   NEW REY   .1303027E+04   NEW DSTZ   .7745771E-03
 DR=  -.4966731E-01   DS=   .1168332E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .2014072939925E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.25199339   BETA=      .55799972         OMEGA=      -.2674610682019E-04  .4857964357283E-02

    GROUP VELOCITY COMPUTED
         VA =  .7114041510804E+00  .5151035347171E-01     VB =  .3259677436511E+00  .2361504053674E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.25209984   BETA=      .55832029         OMEGA=       .2006013857372E-05  .4860061576195E-02
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    GROUP VELOCITY COMPUTED
         VA = .7113575609312E+00  .5136319814036E-01      VB = .3259420413363E+00  .2352625407878E-01
                  ARG =     .80187456E+01
         XLENC =    .99306762E-03      PSI=  88.169123      PHI=        26.131437      RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   13   X/C =    .0549125   IS N =  8.541
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   14   PREVIOUS RADIUS    .3755146E+05   ORIGINAL REY   .1765303E+04   ORIGINAL DSTZ   .1047485E-02
LOCAL MACH NO. =  1.121
STATION NO   14   NEW RADIUS    .3755137E+05   NEW REY   .1765294E+04   NEW DSTZ   .1047480E-02
 DR=  -.8681133E-01   DS=   .2084057E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .2691291730686E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=      -.31495850    BETA=       .68453501           OMEGA=       -.1641053444518E-03  .4005424286420E-02

    GROUP VELOCITY COMPUTED
         VA =  .7334940873102E+00  .6538284671903E-01      VB =  .3378941960084E+00  .3008123612192E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=      -.31398221    BETA=       .68290934           OMEGA=        .2615562012023E-05  .4020285557096E-02

    GROUP VELOCITY COMPUTED
         VA =  .7329917706124E+00  .6507017979747E-01      VB =  .3377131550333E+00  .2993036863926E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=      -.31398114    BETA=       .68290723           OMEGA=        .2691319495303E-05  .4020292335182E-02

    GROUP VELOCITY COMPUTED
         VA =  .7329914412079E+00  .6507033075760E-01      VB =  .3377130550612E+00  .2993047063043E-01
```

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MAIN OPTIMIZER LOOP, NUMB=    4

  ALPHA=     -.31221589   BETA=       .67907584          OMEGA=       .2587164698480E-05  .4020204058688E-02

    GROUP VELOCITY COMPUTED
         VA =  .7327100220783E+00  .6588758322319E-01     VB =  .3376635709897E+00  .3040586258637E-01


MAIN OPTIMIZER LOOP, NUMB=    5

  ALPHA=     -.31302672   BETA=       .68083560          OMEGA=       .2636170095930E-05  .4020288506276E-02

    GROUP VELOCITY COMPUTED
         VA =  .7328396277390E+00  .6551234523742E-01     VB =  .3376864788988E+00  .3018758725935E-01


MAIN OPTIMIZER LOOP, NUMB=    6

  ALPHA=     -.31302737   BETA=       .68083718          OMEGA=       .2691271769006E-05  .4020293469636E-02

    GROUP VELOCITY COMPUTED
         VA =  .7328396151126E+00  .6551179113518E-01     VB =  .3376864456911E+00  .3018727534960E-01
                   APG =     .47565597E+01
         XLENC =    .10978688E-02      PSI=  88.830130     PHI=        25.861172      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    14    X/C =    .0831798    IS N =  9.873
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   15    PREVIOUS RADIUS    .3755137E+05   ORIGINAL REY    .2184070E+04   ORIGINAL DSTZ   .1296816E-02
LOCAL MACH NO. =   1.115
STATION NO   15    NEW RADIUS    .3755127E+05   NEW REY    .2184057E+04   NEW DSTZ    .1296808E-02
 DP=  -.1038858E+00   DS=    .2482361E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .3347197579777E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.36878105   BETA=       .78122205          OMEGA=      -.7485768166168E-04  .2624471678412E-02

    GROUP VELOCITY COMPUTED
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        VA =  .7583641058330E+00  .6177951176931E-01     VB =  .3566137387973E+00  .2896658503526E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.36599167   BETA=      .77550953          OMEGA=       .3116317151995E-05  .2631112256890E-02

    GROUP VELOCITY COMPUTED
        VA =  .7578482654531E+00  .6269742115289E-01     VB =  .3564587774534E+00  .2947040527538E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.36516951   BETA=      .77376222          OMEGA=       .3339548881594E-05  .2631123433905E-02

    GROUP VELOCITY COMPUTED
        VA =  .7577192950180E+00  .6309516309936E-01     VB =  .3564227121281E+00  .2968657871394E-01
                    ARG =     .24229931E+01
        XLENC =    .11903996E-02      PSI=  89.300221      PHI=       25.964117     RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   15   X/C =    .1171658   IS N = 10.764
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   16   PREVIOUS RADIUS   .3755127E+05   ORIGINAL REY   .2545447E+04   ORIGINAL DSTZ   .1512918E-02
LOCAL MACH NO. =  1.106
STATION NO   16   NEW RADIUS   .3755114E+05   NEW REY   .2545427E+04   NEW DSTZ   .1512906E-02
 DR=  -.1215782E+00   DS=   .2856223E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .3930716243690E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.38811052   BETA=      .80708491          OMEGA=      -.2405873090089E-05  .1476155415158E-02

    GROUP VELOCITY COMPUTED
        VA =  .7767476230041E+00  .6142496554550E-01     VB =  .3722523900821E+00  .2941956565944E-01


MAIN OPTIMIZER LOOP, NUMB=    2
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  ALPHA=     -.38732430   BETA=      .80546140          OMEGA=       .3928613790402E-05  .1476664709089E-02

    GROUP VELOCITY COMPUTED
         VA =  .7766300045095E+00  .6177021332021E-01     VB =  .3722119081858E+00  .2960189343777E-01
                   APG =     .11333318E+01
         XLENC =   .13294916E-02      PSI=  89.569145      PHI=        26.112309      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    16   X/C =    .1563292    IS N = 11.272
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    17   PREVIOUS RADIUS    .3755114E+05   ORIGINAL REY    .2850489E+04   ORIGINAL DSTZ    .1695941E-02
LOCAL MACH NO. =   1.097
STATION NO    17   NEW RADIUS    .3755101E+05   NEW REY    .2850462E+04   NEW DSTZ    .1695925E-02
 DR=  -.1379537E+00   DS=    .3191980E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .4433083934269E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.40482396   BETA=      .83075061          OMEGA=       .1696588876755E-05  .7043999935039E-03

    GROUP VELOCITY COMPUTED
         VA =  .7903494261697E+00  .6388096594524E-01     VB =  .3838942109141E+00  .3101664455340E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.40409024   BETA=      .82924719          OMEGA=       .4435532372951E-05  .7046271819108E-03

    GROUP VELOCITY COMPUTED
         VA =  .7902576883353E+00  .6423509347886E-01     VB =  .3838601651059E+00  .3120014296172E-01
                   APG =     .47291669E+00
         XLENC =   .14439320E-02      PSI=  89.729864      PHI=        26.249832      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    17   X/C =    .2000761    IS N = 11.528
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    18   PREVIOUS RADIUS    .3755101E+05   ORIGINAL REY    .3126947E+04   ORIGINAL DSTZ    .1861922E-02
LOCAL MACH NO. =   1.091
STATION NO    18   NEW RADIUS    .3755085E+05   NEW REY    .3126911E+04   NEW DSTZ    .1861901E-02
 DR=  -.1521683E+00   DS=    .3482761E+00
```

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NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .4889094633830E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.41288722   BETA=      .83982634          OMEGA=       .4418737863171E-05  .2298915280910E-03

    GROUP VELOCITY COMPUTED
         VA =  .7998727828430E+00  .6888947563063E-01    VB =  .3921572868823E+00  .3376859998005E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.41238724   BETA=      .83880774          OMEGA=       .4893776010687E-05  .2299332589000E-03

    GROUP VELOCITY COMPUTED
         VA =  .7998243533760E+00  .6915053701339E-01    VB =  .3921390926055E+00  .3390249326799E-01
                   ARG =    .13863535E+00
         XLENC =   .15644957E-02      PSI=  89.827351      PHI=       26.352824     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   18   X/C =    .2477751   IS N = 11.694
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   19   PREVIOUS RADIUS   .3755085E+05   ORIGINAL REY   .3372217E+04   ORIGINAL DSTZ   .2009539E-02
LOCAL MACH NO. =   1.086
STATION NO   19   NEW RADIUS    .3755059E+05   NEW REY   .3372170E+04   NEW DSTZ   .2009511E-02
 DR=  -.1639463E+00   DS=   .3724240E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5298978316786E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.43489440   BETA=      .87829333          OMEGA=       .1090422020422E-05 -.1179830376242E-03

    GROUP VELOCITY COMPUTED
         VA =  .8088370758707E+00  .8171172762463E-01    VB =  .3994865047039E+00  .4034859120320E-01


MAIN OPTIMIZER LOOP, NUMB=    2
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ALPHA=     -.43386117   BETA=      .87621191          OMEGA=       .5309098106640E-05 -.1175523831376E-03

  GROUP VELOCITY COMPUTED
       VA =  .8088007577172E+00  .8221716546610E-01     VB =  .3994777201753E+00  .4060644838271E-01

$$$ STABLE REGION ENCOUNTERED--ICON =      1  WAS SELECTED----PROGRAM CONTINUES$$$

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5721943041057E-05


       NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
       USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

          .1224006927691E-02 -.4010047127179E-03


ALPHA=     -.41600708   BETA=      .83701838          OMEGA =      .1242961083978E-02 -.4245927748692E-03

IBEGIN =1 FAILED TO FIND ACCURATE UNSTABLE            MODE OF WAVE NUMBER WAVE=     .934699    X/C =     .352281AT STATION   20
PROCEEDING TO NEXT STATION


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .6180139653825E-05


       NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LEAST STABLE MODE WILL BE
       USED IN SUBSEQUENT LOCAL EIGENVALUE SEARCH. THIS IS :

          .6277437661096E-03 -.7490187091528E-03


ALPHA=     -.41882036   BETA=      .83561425          OMEGA =      .6519357601405E-03 -.7745326104383E-03

IBEGIN =1 FAILED TO FIND ACCURATE UNSTABLE            MODE OF WAVE NUMBER WAVE=     .934699    X/C =     .407621AT STATION   21
PROCEEDING TO NEXT STATION


NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .6775299999655E-05

ALPHA=     -.42289947   BETA=      .83355726          OMEGA =      .5800802905648E-02  .1701666205325E-03
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```
INITIAL STATION OPTIMIZER LOOP

 ALPHA=     -.43054296   BETA=      .82962058          OMEGA=      .6978180690320E-05  .5988353758665E-03
   GROUP VELOCITY COMPUTED
        VA =  .5802826204614E+00 -.2922598055321E-01     VB =  .2989961610989E+00 -.1615123584243E-01
 ALPHA=     -.44017638   BETA=      .84831363          OMEGA=      .6775304351029E-05  .5774034784886E-03
   GROUP VELOCITY COMPUTED
        VA =  .5802843539018E+00 -.2629401673884E-01     VB =  .2990862219644E+00 -.1481856511769E-01


INITIAL STATION OPTIMIZER LOOP

 ALPHA=     -.44017638   BETA=      .84831363          OMEGA=      .6775304351029E-05  .5774034784886E-03
   GROUP VELOCITY COMPUTED
        VA =  .5802843539018E+00 -.2629401673884E-01     VB =  .2990862219644E+00 -.1481856511769E-01
 ALPHA=     -.37003931   BETA=      .71223433          OMEGA=      .4804559903748E-04  .6559136255240E-03
   GROUP VELOCITY COMPUTED
        VA =  .5780425041455E+00 -.4655094758450E-01     VB =  .2973768465155E+00 -.2395053555387E-01


END OF INITIAL STATION OPTIMIZER AT STATION      22   X/C =     .463998   FINAL RESULTS ARE
 ALPHA=     -.36997557   BETA=      .71197166          OMEGA=      .6788187212235E-05  .6592229511019E-03
   GROUP VELOCITY COMPUTED
        VA =  .5777740179530E+00 -.4637886804635E-01     VB =  .2972349185533E+00 -.2386919545472E-01
                  ARG =     .40337084E+00
        XLENC =   .24620808E-02     PSI=  90.522151      PHI=      26.936634     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
 N FACTOR AT INITIAL STATION NO.      22  IS N=    .075
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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STATION NO   23   PREVIOUS RADIUS    .3755069E+05   ORIGINAL REY   .4374243E+04   ORIGINAL DSTZ   .2623657E-02
LOCAL MACH NO. =  1.047
STATION NO   23   NEW RADIUS   .3755056E+05   NEW REY   .4374175E+04   NEW DSTZ   .2623616E-02
 DR=  -.1273992E+00   DS=   .2784932E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .7127179893611E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.37241344   BETA=     .70497808          OMEGA=      .72012770696 78E-05  .1507671209125E-02

    GROUP VELOCITY COMPUTED
         VA =  .5681794220404E+00 -.5414784529816E-01     VB =  .2970502847518E+00 -.2831185039967E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.37228568   BETA=     .70473347          OMEGA=      .7128023356953E-05  .1507669391670E-02

    GROUP VELOCITY COMPUTED
         VA =  .5681690883728E+00 -.5418490103223E-01     VB =  .2970435058041E+00 -.2832816270467E-01
                   ARG =     .89630961E+00
         XLENC =    .25853469E-02      PSI=  90.713247      PHI=       27.132485      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   23   X/C =   .5017737   IS N =   .255
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   24   PREVIOUS RADIUS   .3755056E+05   ORIGINAL REY   .4333211E+04   ORIGINAL DSTZ   .2602263E-02
LOCAL MACH NO. =  1.040
STATION NO   24   NEW RADIUS   .3755043E+05   NEW REY   .4333137E+04   NEW DSTZ   .2602218E-02
 DR=  -.1291116E+00   DS=   .2786739E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .7104058942383E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.37625460   BETA=     .71007652          OMEGA=      .7205352974255E-05  .1647168424501E-02

    GROUP VELOCITY COMPUTED
```

```
VA =  .5961431180654E+00 -.5918603142145E-01     VB =  .3132929890958E+00 -.3111727506387E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=      -.37574912   BETA=      .70911437          OMEGA=        .7106155719840E-05  .1647157207480E-02

    GROUP VELOCITY COMPUTED
         VA =  .5961060266438E+00 -.5933295343950E-01     VB =  .3132673781634E+00 -.3118293197513E-01
                  APG =     .93996740E+00
         XLENC =   .25467130E-02     PSI=  90.671054      PHI=       27.247223     RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   24   X/C =    .5394315    IS N =    .511
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   25   PREVIOUS RADIUS    .3755043E+05   ORIGINAL REY    .4205439E+04   ORIGINAL DSTZ    .2527792E-02
LOCAL MACH NO. =  1.036
STATION NO   25   NEW RADIUS    .3755031E+05   NEW REY    .4205359E+04   NEW DSTZ    .2527744E-02
 DR=  -.1286786E+00   DS=   .2756133E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .6924746699810E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=      -.35082617   BETA=      .65995920          OMEGA=        .1447132990030E-04  .1477425302737E-02

    GROUP VELOCITY COMPUTED
         VA =  .6137133867895E+00 -.4963428505973E-01     VB =  .3236211308863E+00 -.2615706540941E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=      -.35150364   BETA=      .66122061          OMEGA=        .6931376766242E-05  .1478080635297E-02

    GROUP VELOCITY COMPUTED
         VA =  .6137433617066E+00 -.4939454170860E-01     VB =  .3236439877030E+00 -.2604884731260E-01
                  APG =     .84275258E+00
         XLENC =   .26511311E-02     PSI=  90.666871      PHI=       27.327986     RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   25   X/C =    .5767479    IS N =    .758
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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STATION NO   26   PREVIOUS RADIUS   .3755031E+05   ORIGINAL REY   .4113825E+04   ORIGINAL DSTZ   .2478775E-02
LOCAL MACH NO. =  1.025
STATION NO   26   NEW RADIUS   .3755018E+05   NEW REY   .4113740E+04   NEW DSTZ   .2478724E-02
 DR=  -.1272790F+00   DS=   .2728709E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .6852394041831E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.30923167   BETA=      .57027420          OMEGA=       .3923337979568E-04  .1577374116372E-02

    GROUP VELOCITY COMPUTED
         VA =  .5896690040591E+00 -.3093058086873E-01     VB =  .3161532542617E+00 -.1656833301431E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.30970015   BETA=      .57104556          OMEGA=       .6861869283846E-05  .1579100674042E-02

    GROUP VELOCITY COMPUTED
         VA =  .5895659327353E+00 -.3062337379585E-01     VB =  .3160996706120E+00 -.1642826057310E-01
                 ARG =     .95231754E+00
         XLENC =   .29967996E-02       PSI=  90.932089       PHI=       27.540433     RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   26    X/C =    .6135035    IS N =  1.003
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   27   PREVIOUS RADIUS   .3755018E+05   ORIGINAL REY   .3928852E+04   ORIGINAL DSTZ   .2375638E-02
LOCAL MACH NO. =  1.010
STATION NO   27   NEW RADIUS   .3755005E+05   NEW REY   .3928764E+04   NEW DSTZ   .2375585E-02
 DR=  -.1268526F+00   DS=   .2684592E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .6647912459494E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.28957665   BETA=      .51974340          OMEGA=       .2028411666308E-04  .1860522048887E-02

    GROUP VELOCITY COMPUTED
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        VA =  .5690451887155E+00 -.2446429506143E-01     VB =  .3128174141174E+00 -.1341589558161E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=      -.29026781   BETA=      .52095710          OMEGA=        .6672334306422E-05  .1861188247990E-02

   GROUP VELOCITY COMPUTED
        VA =  .5690320594124E+00 -.2420005352236E-01     VB =  .3128222972326E+00 -.1330826006465E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=      -.29018786   BETA=      .52081160          OMEGA=        .6646010085664E-05  .1861181770545E-02

   GROUP VELOCITY COMPUTED
        VA =  .5690261554321E+00 -.2422419905356E-01     VB =  .3128174773465E+00 -.1331751198269E-01
                  AEG =     .12065475E+01
        XLENC =    .31294542E-02     PSI=  91.297838     PHI=       27.827840     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   27   X/C =    .6494943   IS N =  1.293
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   28   PREVIOUS RADIUS    .3755005E+05   ORIGINAL REY   .3676354E+04   ORIGINAL DSTZ   .2233008E-02
LOCAL MACH NO. =    .992
STATION NO   28   NEW RADIUS   .3754992E+05   NEW REY   .3676265E+04   NEW DSTZ   .2232954E-02
 DR=  -.1268047E+00   DS=   .2632212E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .6340447958116E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=      -.28264223   BETA=      .49354608          OMEGA=        .1048247755078E-04  .2174478929513E-02

   GROUP VELOCITY COMPUTED
        VA =  .5675531212868E+00 -.1933229717527E-01     VB =  .3205423022464E+00 -.1087258414924E-01


MAIN OPTIMIZER LOOP, NUMB=    2
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  ALPHA=     -.28341948   BETA=      .49490936          OMEGA=       .6379715058244E-05  .2174729010233E-02

    GROUP VELOCITY COMPUTED
         VA =  .5675661870967E+00 -.1910020346296E-01     VB =  .3205699722844E+00 -.1078858302088E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.28341124   BETA=      .49489463          OMEGA=       .6340175034900E-05  .2174729483665E-02

    GROUP VELOCITY COMPUTED
         VA =  .5675657252498E+00 -.1910236565181E-01     VB =  .3205694882863E+00 -.1078931948311E-01
                      ARC =     .14941159E+01
         XLENC =   .20751451E-02     PSI=  91.624809     PHI=       28.173485     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   28   X/C =   .6845321   IS N =  1.648
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   29   PREVIOUS RADIUS   .3754992E+05   ORIGINAL REY   .3387745E+04   ORIGINAL DSTZ   .2070488E-02
LOCAL MACH NO. =   .971
STATION NO   29   NEW RADIUS   .3754980E+05   NEW REY   .3387658E+04   NEW DSTZ   .2070435E-02
 DR=  -.1263501E+00   DS=   .2569196E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5988373962540E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.27200463   BETA=      .46005673          OMEGA=       .1540600834319E-04  .2341477620202E-02

    GROUP VELOCITY COMPUTED
         VA =  .5701135005185E+00 -.1111507536224E-01     VB =  .3322505822139E+00 -.6390131248089E-02


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.27326460   BETA=      .46219040          OMEGA=       .6085502109354E-05  .2341885026253E-02

    GROUP VELOCITY COMPUTED
         VA =  .5700898767210E+00 -.1075499956340E-01     VB =  .3322776018517E+00 -.6270644678998E-02
```

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MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.27323576    BETA=      .46214063          OMEGA=       .5987154846090E-05  .2341883754172E-02

    GROUP VELOCITY COMPUTED
         VA =  .5700893408426E+00 -.1076217728526E-01     VB =  .3322763300229E+00 -.6272807979785E-02
                   APG =     .17141738E+01
         XLFNC =    .3028866BE-02      PSI=  91.977955     PHI=       28.615126     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   29    X/C =    .7184489    IS N =  2.060
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   30   PREVIOUS RADIUS    .3754980E+05   ORIGINAL REY   .3066547E+04   ORIGINAL DSTZ    .1889562E-02
LOCAL MACH NO. =    .945
STATION NO   30   NEW RADIUS    .3754967E+05    NEW REY    .3066463E+04    NEW DSTZ    .1889510E-02
 DR=  -.1258000E+00   DS=    .2498232E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .5588279381321E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.26136020    BETA=      .42681368          OMEGA=       .1778669128332E-04  .2348298012401E-02

    GROUP VELOCITY COMPUTED
         VA =  .5772903962710E+00 -.2090084197649E-02     VB =  .3485621840429E+00 -.1142231272653E-02


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.26286865    BETA=      .42927698          OMEGA=       .5741833105701E-05  .2348655498033E-02

    GROUP VELOCITY COMPUTED
         VA =  .5772071985638E+00 -.1695472661305E-02     VB =  .3485716909643E+00 -.1026753041075E-02


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.26283392    BETA=      .42921903          OMEGA=       .5586466024323E-05  .2348651984610E-02
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GROUP VELOCITY COMPUTED
     VA =  .5772077527280E+00 -.1703138333673E-02     VB =  .3485706296846E+00 -.1028608100271E-02
               ARG =     .18434067E+01
     XLENC =   .29485740E-02     PSI=  92.326117     PHI=       29.155091     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   30   X/C =   .7510948    IS N =  2.505
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   31   PREVIOUS RADIUS   .3754967E+05   ORIGINAL REY   .2752733E+04   ORIGINAL DSTZ   .1715035E-02
LOCAL MACH NO. =    .915
STATION NO   31   NEW RADIUS   .3754955E+05   NEW REY   .2752653E+04   NEW DSTZ   .1714985E-02
 DR=  -.1251197E+00    DS=   .2420391E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5213395294361E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.25191517   BETA=      .39527064          OMEGA=       .1857740290672E-04  .2263681045811E-02

   GROUP VELOCITY COMPUTED
     VA =  .5851753333278E+00  .7164250378662E-02     VB =  .3680171826137E+00  .4648113577995E-02


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.25353535   BETA=      .39781054          OMEGA=       .5415829349521E-05  .2263888863129E-02

   GROUP VELOCITY COMPUTED
     VA =  .5850266496172E+00  .7535105207132E-02     VB =  .3680005583335E+00  .4736047113268E-02


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.25349419   BETA=      .39774456          OMEGA=       .5210795125804E-05  .2263881286004E-02

   GROUP VELOCITY COMPUTED
     VA =  .5850288647886E+00  .7527415103770E-02     VB =  .3679999799320E+00  .4734853656164E-02
               ARG =     .19099567E+01
     XLENC =   .2855774CE-02     PSI=  92.681031     PHI=       29.829346     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
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N FACTOR AT STATION   31   X/C =   .7823378   IS N =  2.959
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   32   PREVIOUS RADIUS   .3754955E+05   ORIGINAL REY   .2499824E+04   ORIGINAL DSTZ   .1581701E-02
LOCAL MACH NO. =   .879
STATION NO   32   NEW RADIUS   .3754942E+05   NEW REY   .2499747E+04   NEW DSTZ   .1581652E-02
 DR=  -.1245426E+00   DS=   .2339066E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .4978507990704E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.24300983   BETA=     .36972172        OMEGA=     .1416792495919E-04  .2274252011877E-02

    GROUP VELOCITY COMPUTED
         VA =  .5337268963256E+00  .1631217248159E-01     VB =  .3866522132988E+00  .1092424567747E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.24922288   BETA=     .37152929        OMEGA=     .5133851089106E-05  .2274260543573E-02

    GROUP VELOCITY COMPUTED
         VA =  .5335711868934E+00  .1654866765706E-01     VB =  .3866179260746E+00  .1096085099341E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.24919647   BETA=     .37148903        OMEGA=     .4976505407990E-05  .2274252664312E-02

    GROUP VELOCITY COMPUTED
         VA =  .5335735780985E+00  .1654463029121E-01     VB =  .3866180121606E+00  .1096077311034E-01
                   ARG =     .20540719E+01
         XLENC =   .27769864E-02     PSI=  93.155886     PHI=     30.697824     RFREQ =    .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   32   X/C =   .8120792   IS N =  3.422
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   33   PREVIOUS RADIUS   .3754942E+05   ORIGINAL REY   .2325624E+04   ORIGINAL DSTZ   .1505221E-02
LOCAL MACH NO. =   .834
STATION NO   33   NEW RADIUS   .3754930E+05   NEW REY   .2325548E+04   NEW DSTZ   .1505172E-02
 DR=  -.1249356E+00   DS=   .2262134E+00
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NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .4961147767440E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.25438495    BETA=      .35317738          OMEGA=       .7093070082101E-05  .2565423900485E-02

    GROUP VELOCITY COMPUTED
          VA =  .5672020579822E+00  .2222973591508E-01     VB =  .4036210957752E+00  .1587549214702E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.25489666    BETA=      .35389120          OMEGA=       .5017524915153E-05  .2565433226747E-02

    GROUP VELOCITY COMPUTED
          VA =  .5671252631269E+00  .2230173901311E-01     VB =  .4036016927047E+00  .1587107670353E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.25489467    BETA=      .35388825          OMEGA=       .4960971194346E-05  .2565430717456E-02

    GROUP VELOCITY COMPUTED
          VA =  .5671253841843E+00  .2230164005617E-01     VB =  .4036016443340E+00  .1587122498645E-01
                    ARG =     .2448589OE+01
          XLENC =    .27105723E-02      PSI=  93.894977      PHI=       31.868879      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   33    X/C =    .8402819    IS N =  3.932
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   34   PREVIOUS RADIUS    .3754930E+05   ORIGINAL REY    .2189704E+04   ORIGINAL DSTZ   .1461556E-02
LOCAL MACH NO. =     .782
STATION NO   34   NEW RADIUS    .3754917E+05    NEW REY    .2189629E+04    NEW DSTZ    .1461506E-02
 DR=  -.1275564E+00    DS=    .2199934E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5096034173784E-05
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MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.27010355   BETA=       .34487647          OMEGA=        .5288334587347E-05  .3197513006161E-02

    GROUP VELOCITY COMPUTED
         VA =  .5518517819321E+00  .2201806333364E-01     VB =  .4272493493704E+00  .1705608783522E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.27019313   BETA=       .34499172          OMEGA=        .5103818996717E-05  .3197518118769E-02

    GROUP VELOCITY COMPUTED
         VA =  .5518384223105E+00  .2202732731639E-01     VB =  .4272461685858E+00  .1705275691708E-01
                   ARG =      .31348655E+01
         XLENC =    .26194666F-02       PSI=  94.735735      PHI=        33.331687     RFREQ =       .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   34    X/C =    .8669769    IS N =  4.546
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    35    PREVIOUS RADIUS    .3754917E+05    ORIGINAL REY    .2030281E+04    ORIGINAL DSTZ    .1400830E-02
LOCAL MACH NO. =     .736
STATION NO    35    NEW RADIUS    .3754904E+05    NEW REY    .2030208E+04    NEW DSTZ    .1400779E-02
 DR=  -.1310102E+C0    DS=    .2140041E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .5161865990564E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.27813298   BETA=       .33237010          OMEGA=        .5825519973963E-05  .3688537202610E-02

    GROUP VELOCITY COMPUTED
         VA =  .5613937395890E+00  .1990842229902E-01     VB =  .4644879473402E+00  .1650988637870E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.27841968   BETA=       .33271518          OMEGA=        .5186277816873E-05  .3688554843469E-02

    GROUP VELOCITY COMPUTED
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```
   VA =  .5613523941563E+00  .1993674917136E-01     VB =  .4644784045700E+00  .1649731931902E-01


MAIN OPTIMIZER LOOP, NUMB=    3

 ALPHA=     -.27842827   BETA=      .33272551          OMEGA=       .5162472766195E-05  .3688555009188E-02

   GROUP VELOCITY COMPUTED
        VA =  .5613511439256E+00  .1993760922728E-01     VB =  .4644781102414E+00  .1649695288648E-01
                  ARG =     .3614086665E+01
        XLENC =   .25358087E-02     PSI=  95.121927     PHI=       34.800853     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   35   X/C =   .8921254   IS N =  5.268
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   36   PREVIOUS RADIUS   .3754904E+05   ORIGINAL REY   .1855944E+04   ORIGINAL DSTZ   .1317961E-02
LOCAL MACH NO. =    .700
STATION NO   36   NEW RADIUS   .3754891E+05   NEW REY   .1855874E+04   NEW DSTZ   .1317912E-02
 DP=  -.1298953E+00   DS=   .2037594E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .5079497950227E-05


MAIN OPTIMIZER LOOP, NUMB=    1

 ALPHA=     -.27263066   BETA=      .31412585          OMEGA=       .1169464418192E-04  .3651719925605E-02

   GROUP VELOCITY COMPUTED
        VA =  .5881236949189E+00  .2005965463925E-01     VB =  .5048332519032E+00  .1733582960697E-01


MAIN OPTIMIZER LOOP, NUMB=    2

 ALPHA=     -.27353046   BETA=      .31516101          OMEGA=       .5173479769168E-05  .3651646348484E-02

   GROUP VELOCITY COMPUTED
        VA =  .5879920466605E+00  .2016713685913E-01     VB =  .5047982710097E+00  .1731060201581E-01


MAIN OPTIMIZER LOOP, NUMB=    3
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```
ALPHA=    -.27350730   BETA=     .31513384         OMEGA=      .5078149814569E-05  .3651640769169E-02

   GROUP VELOCITY COMPUTED
        VA =  .5879949045307E+00  .2016506565053E-01     VB =  .5047987227713E+00  .1731186181792E-01
                 ARG =    .35753911E+01
        XLENC =   .24806019E-02      PSI=  94.939520      PHI=       36.015293     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   36   X/C =   .9154648   IS N =  6.000
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   37   PREVIOUS RADIUS   .3754891E+05   ORIGINAL REY   .1704266E+04   ORIGINAL DSTZ   .1239191E-02
LOCAL MACH NO. =   .674
STATION NO   37   NEW RADIUS   .3754879E+05   NEW REY   .1704199E+04   NEW DSTZ   .1239143E-02
 DP=  -.1218447E+00   DS=   .1870544E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .4946973839990E-05


MAIN OPTIMIZER LOOP, NUMB=    1

 ALPHA=    -.26101590   BETA=     .29449481         OMEGA=      .1681931963717E-04  .3292373988393E-02

   GROUP VELOCITY COMPUTED
        VA =  .6133284325397E+00  .2257978837202E-01     VB =  .5378973641090E+00  .1998163462227E-01


MAIN OPTIMIZER LOOP, NUMB=    2

 ALPHA=    -.26237492   BETA=     .29602234         OMEGA=      .5110665419230E-05  .3292195570730E-02

   GROUP VELOCITY COMPUTED
        VA =  .6131194729866E+00  .2275061926561E-01     VB =  .5378321329478E+00  .1994975469315E-01


MAIN OPTIMIZER LOOP, NUMB=    3

 ALPHA=    -.26232271   BETA=     .29596252         OMEGA=      .4944331754311E-05  .3292184839432E-02

   GROUP VELOCITY COMPUTED
        VA =  .6131262136731E+00  .2274590334800E-01     VB =  .5378335267099E+00  .1995262073159E-01
                 ARG =    .32575451E+01
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         XLENC =   .24608364E-02      PSI=  94.572400      PHI=        36.979205      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    37    X/C =     .9366028    IS N =  6.640
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   38   PREVIOUS RADIUS   .3754879E+05   ORIGINAL REY   .1586253E+04   ORIGINAL DSTZ   .1176482E-02
LOCAL MACH NO. =    .653
STATION NO   38   NEW RADIUS   .3754868E+05   NEW REY   .1586188E+04   NEW DSTZ   .1176434E-02
 DR=  -.1090653E+00   DS=   .1653912E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=   .4832871909076E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.25077882   BETA=      .27828044           OMEGA=       .1375947455115E-04  .2881463496748E-02

    GROUP VELOCITY COMPUTED
         VA =  .6315838462240E+00  .2652994656233E-01     VB =  .5635440108636E+00  .2381255333968E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.25182343   BETA=      .27943534           OMEGA=       .4938288727437E-05  .2881259561950E-02

    GROUP VELOCITY COMPUTED
         VA =  .6314190019516E+00  .2667008167573E-01     VB =  .5634857722238E+00  .2379589384662E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.25178930   BETA=      .27939690           OMEGA=       .4831180099818E-05  .2881252192214E-02

    GROUP VELOCITY COMPUTED
         VA =  .6314235027332E+00  .2666684288956E-01     VB =  .5634869002491E+00  .2379764837498E-01
                   APG =     .28939599E+01
         XLENC =   .24566290E-02      PSI=  94.255202      PHI=        37.769439      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    38    X/C =     .9551658    IS N =  7.148
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   39   PREVIOUS RADIUS   .3754868E+05   ORIGINAL REY   .1505156E+04   ORIGINAL DSTZ   .1135914E-02
LOCAL MACH NO. =    .636
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STATION NO   39   NEW RADIUS    .3754858E+05    NEW REY    .1505093E+04    NEW DSTZ    .1135867E-02
 DR=  -.9346422E-01   DS=    .1403730E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .4781820911516E-05


MAIN OPTIMIZER LOOP, NUMB=     1

  ALPHA=      -.24272688    BETA=       .26454756            OMEGA=        .1065766230111E-04  .2523879381023E-02

    GROUP VELOCITY COMPUTED
         VA =  .6393822815288E+00  .3173663444194E-01     VB =  .5812079220223E+00  .2896039720340E-01


MAIN OPTIMIZER LOOP, NUMB=     2

  ALPHA=      -.24354832    BETA=       .26543892            OMEGA=        .4857486790722E-05  .2523708687422E-02

    GROUP VELOCITY COMPUTED
         VA =  .6392485776493E+00  .3183304233029E-01     VB =  .5811565944348E+00  .2893708348938E-01


MAIN OPTIMIZER LOOP, NUMB=     3

  ALPHA=      -.24352620    BETA=       .26541445            OMEGA=        .4780652478490E-05  .2523703010865E-02

    GROUP VELOCITY COMPUTED
         VA =  .6392516314321E+00  .3183129100702E-01     VB =  .5811574877177E+00  .2893849925196E-01
                    ARG =      .25717514E+01
         XLENC =    .24766431E-02      PSI=  94.086966      PHI=        38.450231      RFREQ =      .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    39   X/C =    .9708384    IS N =  7.532
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   40   PREVIOUS RADIUS    .3754858E+05   ORIGINAL REY   .1450461E+04   ORIGINAL DSTZ   .1112419E-02
LOCAL MACH NO. =    .621
STATION NO   40   NEW RADIUS    .3754851E+05   NEW REY    .1450399E+04   NEW DSTZ    .1112371E-02
 DR=  -.7590558E-01   DS=    .1128399E+00

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .4788217110885E-05
```

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MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.23795537    BETA=      .25418907          OMEGA=       .7580148923956E-05  .2266441667144E-02

    GROUP VELOCITY COMPUTED
         VA =  .6402825075383E+00  .3678718083665E-01     VB =  .5940756631958E+00  .3420380125221E-01


MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.23846861    BETA=      .25473753          OMEGA=       .4830346773140E-05  .2266346934415E-02

    GROUP VELOCITY COMPUTED
         VA =  .6401927030607E+00  .3683914207054E-01     VB =  .5940370769664E+00  .3418177536528E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.23845886    BETA=      .25472695          OMEGA=       .4787653432550E-05  .2266343639630E-02

    GROUP VELOCITY COMPUTED
         VA =  .6401941647131E+00  .3683851574052E-01     VB =  .5940375908180E+00  .3418253628434E-01
                   ARG =     .23328719E+01
         XLENC =   .25038453E-02     PSI=  94.038383      PHI=       39.072186      RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   40    X/C =    .9933592    IS N =  7.809
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO    41    PREVIOUS RADIUS    .3754851E+05   ORIGINAL REY    .1470449E+04   ORIGINAL DSTZ    .1147284E-02
LOCAL MACH NO. =    .606
STATION NO    41    NEW RADIUS    .3754845E+05    NEW REY    .1470384E+04    NEW DSTZ    .1147234E-02
 DR=  -.5656407E-01    DS=    .8315961E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .5054603014354E-05


MAIN OPTIMIZER LOOP, NUMB=    1

  ALPHA=     -.23313114    BETA=      .23909838          OMEGA=       .9243822684372E-05  .1883734346438E-02
```

```
GROUP VELOCI'Y COMPUTED
     VA =  .6049743210877E+00  .5715343150869E-01     VB =  .5842373456074E+00  .5529414049901E-01


MAIN OPTIMIZER LOOP, NUMB=     2

  ALPHA=     -.23376649   BETA=      .23974911           OMEGA=      .5132771783276E-05  .1883445104145E-02

   GROUP VELOCITY COMPUTED
     VA =  .6048192640736E+00  .5721477481530E-01     VB =  .5841474510430E+00  .5525671637441E-01


MAIN OPTIMIZER LOOP, NUMB=     3

  ALPHA=     -.23375086   BETA=      .23973278           OMEGA=      .5053169817571E-05  .1883435913035E-02

   GROUP VELOCITY COMPUTED
     VA =  .6048224863924E+00  .5721397318304E-01     VB =  .5841491224957E+00  .5525834229070E-01
              ARG =     .19524362E+01
     XLEPC =    .26910189E-02      PSI=  94.549622      PHI=       39.726375      RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION    41   X/C =    .9925170    IS N =  7.987
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
STATION NO   42    PREVIOUS RADIUS    .3754845E+05    ORIGINAL REY    .1559347E+04    ORIGINAL DSTZ    .1245618E-02
LOCAL MACH NO. =    .586
STATION NO   42    NEW RADIUS    .3754842E+05    NEW REY    .1559278E+04    NEW DSTZ    .1245563E-02
 DR=  -.3612375E-01    DS=    .5199859E-01

NON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=    .5662188869808E-05


MAIN OPTIMIZER LOOP, NUMB=     1

  ALPHA=     -.23917319   BETA=      .22639237           OMEGA=      .7185909990867E-05  .1030388969117E-02

   GROUP VELOCITY COMPUTED
     VA =  .5104785200018E+00  .7484178805130E-01     VB =  .5354624947680E+00  .7874852657081E-01
```

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```
MAIN OPTIMIZER LOOP, NUMB=    2

  ALPHA=     -.24032833   BETA=      .22749076          OMEGA=       .5934369887051E-05  .1030576016979E-02

    GROUP VELOCITY COMPUTED
         VA =  .5101227066588E+00  .7473200521366E-01     VB =  .5352237961750E+00  .7846436544500E-01


MAIN OPTIMIZER LOOP, NUMB=    3

  ALPHA=     -.24066541   BETA=      .22781153          OMEGA=       .5726134819765E-05  .1030614432212E-02

    GROUP VELOCITY COMPUTED
         VA =  .5100196121702E+00  .7469957554902E-01     VB =  .5351549830776E+00  .7838120074259E-01


MAIN OPTIMIZER LOOP, NUMB=    4

  ALPHA=     -.24066667   BETA=      .22781261          OMEGA=       .5662393630451E-05  .1030605309798E-02

    GROUP VELOCITY COMPUTED
         VA =  .5100189422708E+00  .7469959265293E-01     VB =  .5351544512723E+00  .7838106584360E-01
                   ARG =     .11192516E+01
         XLENC =   .29520C08E-02     PSI=  95.961895     PHI=        40.609609     RFREQ =     .50000000E+00  HZ
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
N FACTOR AT STATION   42   X/C =   .9981435   IS N =  8.067
$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
```

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3. MEAN FLOW PROFILES

The present version of COSAL accepts three-dimensional compressible boundary layer profiles for swept and tapered wings as calculated by Program WING. In this program, the boundary layer flow is analyzed by invoking conical flow similarity transformations. This significantly reduces the complexity of the problem; the analysis, however, is not applicable to the regions near the wing root or the wing tip. A brief description of the program is given below.

3.1 Program Wing

Except for a few modifications concerning the output, Program WING is essentially the same as Program MAIN developed by Cebecci and Kaups [7] for calculation of compressible laminar boundary layers with suction on swept and tapered wings. WING is specifically designed to provide boundary layer profiles appropriate for input to the compressible stability analysis code COSAL.

The coordinate system $(x,\theta,y)^{\dagger}$ used in Program WING is depicted in Fig. 4. The fundamental assumption employed in the analysis is that the wing has a trapezoidal planform and that the spanwise pressure gradient is negligible. As a consequence, the conical flow similarity transformations can be used which enable the governing three-dimensional flow equations to be reduced in a form similar to two-dimensional flow equations. The

† Nomenclature used in WING should not be confused with that used in COSAL.

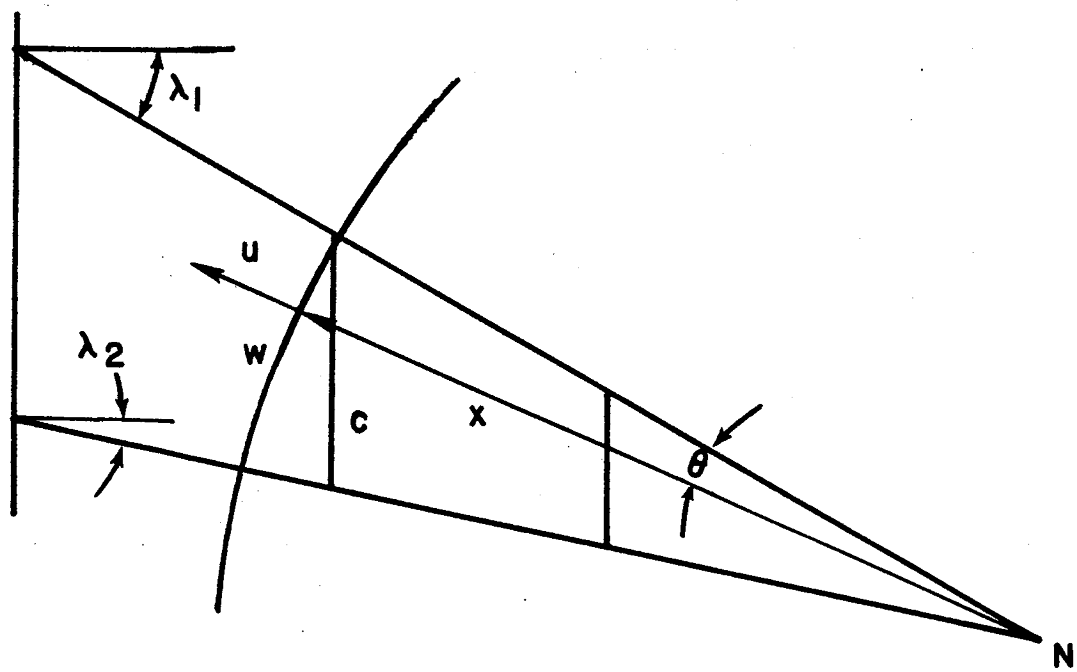

FIGURE 4. COORDINATE SYSTEM USED IN PROGRAM WING.

C-2

conical flow assumption implies that both the airfoil thickness distribution and the spanwise wall mass flow rate distribution are governed by similarity considerations.

The boundary layer calculations are done along the arc formed by the interaction of a sphere of radius x = constant and the conical wing surface. It is assumed that the wing planform is given in terms of the sweep angles λ_1 and λ_2 for the leading and trailing edges, respectively. It is further assumed that the non-dimensional wing thickness distribution ξ/c, $\bar{z}/c$ (see Fig. 5) is specified along a streamwise section with chord length c. This chord intersects the sphere at the wing leading edge as shown in Fig. 4. The above geometrical data is used in WING to calculate the independent variable θ.

The conical flow similarity variable η is defined as

$$d\eta = \sqrt{\frac{\bar{u}_e}{\rho_e \mu_e x}} \quad \rho\, y$$

where y is the (dimensional) normal boundary layer coordinate and ρ and μ are the density and viscosity, respectively, of air. Furthermore, $\bar{u} = -u$ where u is the velocity component along radial coordinate x. The subscript e refers to the boundary layer edge values.

The mass conservation condition is satisfied by introducing a two-component vector potential given as

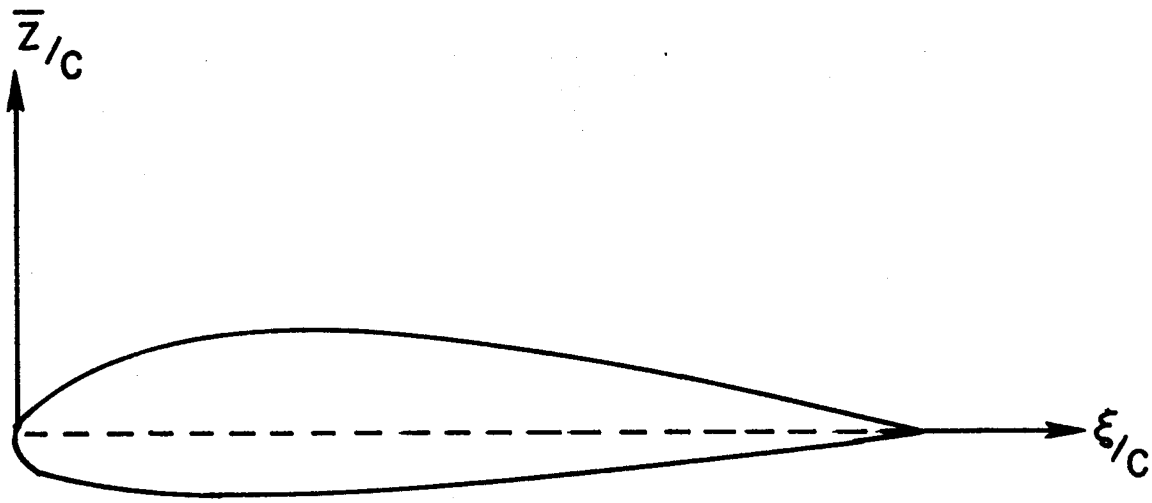

FIGURE 5. STREAMWISE AIRFOIL DEFINITION. (C IS THE AIRFOIL CHORD.)

$$\rho \bar{u} x = \frac{\partial \psi}{\partial y}$$

$$\rho w x = \frac{\partial \Phi}{\partial y}$$

$$\rho v x = \frac{\partial \psi}{\partial x} - \frac{1}{x}\frac{\partial \Phi}{\partial \theta} + (\rho v x)_w$$

where w and v are the velocity components in θ and y directions respectively. The subscript w refers to the wall value.

The vector potential components ψ and Φ are represented in terms of dimensionless parameters f and g as

$$\psi = x^{3/2} \sqrt{\rho_e \mu_e \bar{u}_e}\; f(\eta,\theta)$$

$$\Phi = x^{3/2} \sqrt{\rho_e \mu_e x}\; w_e/\bar{u}_e\; g(\eta,\theta)$$

where

$$f' = u/u_e \text{ and } g' = w/w_e$$

The introduction of the similarity transformations makes the governing equations (see [7]) independent of x and the solution can be obtained by marching in θ direction. The Keller's Box method is used to solve the boundary layer equations. The details of the method can be found in [7].

3.2 Computer Resources

Program WING requires about 75,000 octal words of memory and typical execution time is about 15 seconds on CYBER 175.

3.3 Input/Output

The program card for CDC machines reads

```
PROGRAM WING (INPUT, OUTPUT,TAPE5=INPUT, TAPE6=OUTPUT,
TAPE7)
```

TAPE5 and TAPE6 are input and output units respectively while TAPE7 contains output to be used in stability analysis using COSAL. The control cards needed to run WING are:

.

.

(USER INFORMATIONS)

.

.

```
GET, WING.
FTN,I=WING,OPT=2.
LDSET,PRESETA=NGINF.
LGO.
REWIND,TAPE7.
SAVE,TAPE7=BLDATA.
EXIT.
7/8/9 End of record
Input data
6/7/8/9 End of file
```

The input data to program WING consists of free-stream conditions (M_∞, U_∞, P_∞, T_∞), Prandtl number (Pr), boundary-layer grid parameters (η_∞, $\Delta\eta_1$ ($\equiv h_1$), K), total number of streamwise stations (NZT), leading and trailing edge sweep angles (λ_1, λ_2), and streamwise chord length (c). The geometry of the wing is specified by tabular values of $(\xi/c)_o$ and $(\bar{z}/c)_o$

for a total number of NI points. The pressure distribution and suction quantities are specified by inputting the pressure coefficients C_p and dimensionless suction mass flow rate $(\rho v)_w/(\rho U)_\infty$, as a function of $(\xi/c)_i$. Note that $(\xi/c)_o$ and $(\xi/c)_i$ are not necessarily the same. Upper and lower surfaces are treated as separate cases, the dividing-point being taken as the place where $w_e = 0$. Note that the $(\xi/c)_i$ values must be within the interval of $(\xi/c)_{o,min}$ and $(\xi/c)_{o,max}$.

Description of the Input Data

Card 1	Punched as an 80-column alphanumeric field
TITLE	Description of the case
Card 2	Punched in I1 Format
IWRT	A parameter to control output.
IWRT=3	No extra output (suitable for COSAL) is written, either on TAPE7 or listable output file TAPE6. (Only the output of original program MAIN is written on TAPE6).
IWRT=2	All extra output (to be input to COSAL) are written on TAPE7 and output file TAPE6.
IWRT=1	All extra output is written on output file TAPE6 but is not written on TAPE7.
IWRT=0	All extra output is written on TAPE7 but not on listable output file TAPE6.

Card 3 Punched in 2I3, 3F10.0 format

NI Number of input stations for the streamwise airfoil (Maximum NI = 61)

NZT Number of input stations where C_p is specified (Maximum NZT = 51)

ETAE Estimated value of η_{max} at the first station. (Usually less than 0.5, see section 3.4 on how to estimate η_{max})

DETA1 First $\Delta\eta$-step size, $\Delta\eta_1$

VGP Variable grid parameter (K = 1.0 for uniform grid in η)

Note: the variable grid used in WING is a geometric progression having the property that the ratio of lengths of any two adjacent intervals is a constant; i.e., $\Delta\eta_i = K\Delta\eta_{i-1}$. The distance to the j-th line is given by the following formula:

$$\eta_j = \Delta\eta_1 \ (K^j - 1)/(K - 1) \qquad K > 1$$

The total number of points J can be calculated by the following formula:

$$J = \frac{\ln\ [1 + (K-1)\ (\eta_\infty/\Delta\eta_1)]}{\ln\ K}$$

Card 4 Punched in 8F10.0 format

X Chord length c (maximum length line) in feet for the streamwise airfoil.

SWLE Leading-edge sweep in degrees, λ_1

SWTE Trailing-edge sweep in degrees, λ_2

CMACH Free-stream Mach number. For incompressible flow $M_\infty = 0.0$

UREF Free-stream velocity in feet per second. Input only if $M_\infty = 0.0$

TPRES Free-stream static pressure, in pounds per square feet

TT Free-stream static temperature, in degrees Rankine

Pr Prandtl number

Note: the following must be observed with respect to the sweep angles: $\tan \lambda_1 > \tan \lambda_2 > o$; i.e. both the leading and trailing edges must have swept-back.

<u>Card 5</u> Cards for streamwise airfoil definition in 8F10.0 format

A ξ/c-values of the defining airfoil. Total of NI points. Note: $\xi/c = 0.0$ must be input if calculations contain the leading edge.

<u>Card 6</u> Cards for streamwise airfoil definition in 8F10.0 format

Y $\bar{z}/c$-values of the defining airfoil. Total of NI points. Note: $\bar{z}/c = 0.0$ must be input if calculations contain the leading edge.

Note: the streamwise airfoil definition in terms of ξ/c and $\bar{z}/c$ should be as smooth as possible. The point distribution should be denser near the nose in order to compute the external velocity distribution from the specified pressure distribution.

Card 7 Cards for input-output locations in 8F10.0 format. ξ/c-stations where C_p and suction data is input. Total of NZT points.

Note: $\xi/c = 0.0$ must be input if calculations contain the leading edge.

Card 8 Cards for pressure distribution in 8F10.0 format.

P4 Input C_p-values. Total of NZT points.

Card 9 Cards for mass transfer at the wall in 8F10.0 format.

BLP Input $(\rho v)_w/(\rho U)_\infty$-values. Total of NZT points.

Description of Output Data

1st Line Prints the description of the case.

2nd Line MACHN = Free-stream Mach number

UFS = Free-stream velocity, in fps

PFS = Free-stream pressure, in lb/ft^2

TFS = Free-stream temperature, in degree R

PR = Prandtl number

3rd Line ROFS = Free-stream density, in $slugs/ft^3$

MUFS = Free-stream viscosity, in lb-sec/ft^2

REC = Reynolds number based on free-stream values and streamwise chord = $U_\infty c/\nu_\infty$

4th Line CHORD = Streamwise chord in feet

RADIUS= Radial distance x_o in feet from the cone tip to the leading edge of the defining airfoil (is equal to the coordinate x in boundary-layer equations)

LESW = Leading-edge sweep in degrees

TESW = Trailing-edge sweep in degrees

5th Line NI = Number of input stations for the streamwise airfoil

NZ = Number of input stations at which pressure distribution and mass transfer is specified (equals to the number of output stations)

ETAE = Estimate for η_∞ at the first station

DETA1 = Specified first $\Delta\eta$-step size

VGP = Specified variable grid parameter K

The table STREAMWISE AIRFOIL COORDINATES contain three columns under the following headings:

NI = Point number

X/C = Streamwise airfoil abscissa $(\xi/c)_o$

Z/C = Streamwise airfoil ordinate $(\bar{z}/c)_o$

The table STATION DATA contains ten columns under the following headings:

NZ	=	Sequence number of output station
X/C	=	Streamwise airfoil abscissa, $(\xi/c)_i$
THETA	=	Boundary-layer coordinate θ in the developed plane, in radians
S	=	Surface distance in feet along the x = x section measured from the stagnation line.
CP	=	Input Cp-value
CQK	=	Input $(\rho v)_w/(\rho U)_\infty$-value
UEUFS	=	Calculated u_e/U_∞
WEUFS	=	Calculated w_e/U_∞
DWEUFS	=	Calculated $1/U_\infty w_{\theta_e}$
PEPFS	=	p_e/p_∞

The results from boundary-layer calculations are printed out for each station under a heading giving the station number NZ and the nondimensional chordwise location $(\xi/c)_i$. The first table gives intermediate results from the iterated solutions for f''_w, $\Delta f''_w$, g''_w, and $\Delta g''_w$, respectively. Profiles for the converged solution are presented in the next table under the following headings:

J	=	Point number in the boundary layer
ETA	=	The transformed variable η
F	=	Boundary-layer variable f
U	=	Boundary-layer variable f'
V	=	Boundary-layer variable f"
G	=	Boundary-layer variable g

W = Boundary-layer variable g'

T = Boundary-layer variable g"

TEMP-R = Static temperature ratio in the boundary layer, T/T_e

Y-FT = Distance normal to the surface in feet

Calculated boundary-layer parameters are printed under the heading BOUNDARY-LAYER PARAMETERS, where:

DELSTX = δ_x^* in feet

DELSTZ = δ_θ^* in feet

THETAX = θ_x in feet

THETAZ = θ_θ in feet

CFX = cf_x, local skin-friction coefficient in x-direction

CFZ = cf_θ, local skin-friction coefficient in θ-direction

HX = δ_x^*/θ_x

HZ = $\delta_\theta^*/\theta_\theta$

Quantities printed out under the heading FLOW PARAMETERS pertain to flow properties at the outer edge of the boundary layer, at the wall, and nondimensional mass-transfer parameters. They are

UE = $\bar{u}_e$ in fps

WE = w_e in fps

PE = p_e in lb/ft^2

TE = T_e in deg R

RHOE = ρ_e in $slugs/ft^3$

MUE = μ_e in $lb\text{-}sec/ft^2$

BLP = $(\rho v)_w/(\rho\bar{u})_e\sqrt{R_x}$

SQUIG = $(\rho v)_w/(\rho w)_e\sqrt{w_e s/\nu_e}$

TW = T_w in deg R

RHOW = ρ_w in slugs/ft^3

VW = v_w in fps

CW = $(\rho\mu)_w/(\rho\mu)_e = C_w$

Additional outputs printed starting from station number 2 are (these are generated for use in COSAL and are written on Tape 7):

NZ = Station number

NP = Number of points in boundary layer profile

DESTZ = Boundary layer displacement thickness to be used in stability analysis (= compressible displacement thickness DELSTZ)

RDSTZ = Local Reynolds number to be used in stability analysis. RDSTZ is based on DESTZ and local potential velocity in θ direction, W_e.

Following this are 10 columns lobeled J, Y, WO, W1, W2, UO, U1, U2, TO, T1, T2. These are:

J = Point number in the boundary layer

Y = Distance normal to the surface non-dimensionalized by DESTZ.

WO, UO, TO = Velocity component in θ-direction, velocity component in x-direction and temperature, respectively. Velocity components are scaled with respect to W_e and temperature with respect to T_e.

W1, U1, T1 = First derivatives of WO, UO and TO with respect to Y.

W2, U2, T2 = Second derivatives of WO, UO and TO, respectively.

3.4 Sample Run

Sample output of program WING for the case "YEBZ AIRFOIL UPPER SURFACE, SUCTION U244" is given below. This is a 35° swept infinite span wing of Pfenninger type. To save space, output for only first 10 stations is given instead of all 42 stations.

User's attention is drawn to the higher resolution of airfoil definition near the stagnation point. The boundary layer calculations are started at the stagnation point (NI = 6 in the printout below). A few extra points ahead of the stagnation point are provided for proper interpolation of geometrical data in this region.

It is necessary to input an appropriate value of ETAE (η_∞) for the first calculation station. The boundary layer growth for the later stations is done internally. It should be noted that the input η_∞ for the first station differs considerably from the "usual" two-dimensional cases. It can be shown that the relationship between η_∞ and the "usual" two-dimensional variable, N_∞ , is [7]

$$\eta_\infty = \left(\frac{\bar{u}_e}{w_{\theta_e}} \right)^{\frac{1}{2}} N_\infty$$

where $w_{\theta_e} = \dfrac{dw_e}{d\theta}$

Using $\bar{u}_e/U_\infty = 0.57$ and $w_{\theta_e}/U_\infty = 6.3 \times 10^5$ which are typical for the present test problem, and $N_\infty = 8$, we get $\eta_\infty \approx .0075$.

A quick check of whether appropriate value of ETAE was provided is that calculated V (see printout below) at the edge of the boundary layer should be small (of $O(10^{-10})$). If V is "large", increase ETAE.

1

0 YFBZ AIRFOIL UPPER SURFACE-------SUCTION U244

OMACHN	=	.891170E+00	UES	=	.103338E+04	PES	=	.649900E+03	TES	=	.559700E+03	PR	=	.720000E+00
ORDES	=	.675624E-03	MUES	=	.396386E-06	REC	=	.140909E+08						
CCHORD	=	.800000E+01	RADIUS	=	.375517E+05	LESW	=	.350000E+02	TESW	=	.349900E+02			
ONI	=	49	NZ	=	42	ETAE	=	.750000E-02	DETA1	=	.625000E-04	VGP	=	.105000E+01

0 STREAMWISE AIRFOIL COORDINATES

0 NI	X/C	Z/C
1	.936110E-02	-.609780E-02
2	.562910E-02	-.497260E-02
3	.282090E-02	-.361720E-02
4	.978000E-03	-.226270E-02
5	.804000E-04	-.733900E-03
6	0.	0.
7	.700000E-04	.106260E-02
8	.733400E-03	.318960E-02
9	.186960E-02	.549980E-02
10	.352930E-02	.782780E-02
11	.580450E-02	.101563E-01
12	.869990E-02	.124811E-01
13	.122222E-01	.147930E-01
14	.163775E-01	.170434E-01
15	.266023E-01	.214109E-01
16	.394226E-01	.254637E-01
17	.549125E-01	.291576E-01
18	.730979E-01	.325236E-01
19	.939986E-01	.356189E-01
20	.117166E+00	.384679E-01
21	.142735E+00	.410706E-01
22	.170432E+00	.434160E-01
23	.200076E+00	.454870E-01
24	.231477E+00	.472759E-01
25	.264437E+00	.487626E-01
26	.298749E+00	.499364E-01
27	.334198E+00	.507855E-01
28	.370564E+00	.513001E-01
29	.407621E+00	.514700E-01
30	.445139E+00	.512873E-01
31	.501774E+00	.503311E-01
32	.576749E+00	.477353E-01
33	.613504E+00	.458474E-01
34	.631607E+00	.447510E-01
35	.657143E+00	.422469E-01
36	.684532E+00	.408377E-01
37	.719449E+00	.377039E-01
38	.734940E+00	.359818E-01

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39	.766899E+00	.322350E-01
40	.782338E+00	.302142E-01
41	.826372E+00	.235986E-01
42	.853816E+00	.188081E-01
43	.864977E+00	.163625E-01
44	.904045E+00	.929870E-02
45	.936603E+00	.331420E-02
46	.963381E+00	-.124400E-02
47	.983359E+00	-.436080E-02
48	.995781E+00	-.614890E-02
49	.999584E+00	-.666750E-02

0

STATION DATA

0 NZ	X/C	THETA	S	CP	COL	UEUFS	WEUFS	DWEUFS	PEPFS
1	0.	0.	0.	.765232E+00	0.	.573578E+00	0.	.625951E+06	.142541E+01
2	.700000E-04	.212773E-06	.799000E-02	.752695E+00	0.	.573578E+00	.987427E-01	.410353E+06	.141844E+01
3	.733400E-03	.738763E-06	.277418E-01	.668036E+00	0.	.573578E+00	.276586E+00	.326431E+06	.137138E+01
4	.186860E-02	.125035E-05	.469526E-01	.515057E+00	0.	.573577E+00	.448763E+00	.309271E+06	.128634E+01
5	.352930E-02	.183193E-05	.687921E-01	.337528E+00	-.735000E-03	.573577E+00	.594934E+00	.209012E+06	.118764E+01
6	.580450E-02	.246723E-05	.926487E-01	.171531E+00	-.700000E-03	.573577E+00	.710649E+00	.157572E+06	.109536E+01
7	.869990E-02	.317499E-05	.119226E+00	.205097E-01	-.630000E-03	.573576E+00	.806558E+00	.116322E+06	.101140E+01
8	.122222E-01	.396164E-05	.148766E+00	-.110402E+00	-.530000E-03	.573575E+00	.885394E+00	.861702E+05	.938624E+00
9	.163775E-01	.483291E-05	.181484E+00	-.222460E+00	-.430000E-03	.573575E+00	.950819E+00	.660866E+05	.876328E+00
10	.211690E-01	.579323E-05	.217546E+00	-.320642E+00	-.290000E-03	.573574E+00	.100719E+01	.515758E+05	.821746E+00
11	.266023E-01	.684601E-05	.257080E+00	-.404086E+00	-.163000E-03	.573573E+00	.105472E+01	.398298E+05	.775357E+00
12	.394226E-01	.924501E-05	.347166E+00	-.533843E+00	-.155000E-03	.573570E+00	.112851E+01	.222042E+05	.703221E+00
13	.549125E-01	.120612E-04	.452917E+00	-.605019E+00	-.143000E-03	.573567E+00	.116917E+01	.833506E+04	.663653E+00
14	.831798E-01	.171066E-04	.642383E+00	-.629529E+00	-.143000E-03	.573561E+00	.118324E+01	-.341953E+03	.650027E+00
15	.117166E+00	.231105E-04	.867838E+00	-.620104E+00	-.143000E-03	.573554E+00	.117783E+01	-.116882E+04	.655267E+00
16	.156329E+00	.299935E-04	.112631E+01	-.606649E+00	-.143000E-03	.573546E+00	.117012E+01	-.105264E+04	.662746E+00
17	.200076E+00	.376589E-04	.141416E+01	-.594265E+00	-.143000E-03	.573537E+00	.116303E+01	-.768097E+03	.669631E+00
18	.247775E+00	.460016E-04	.172744E+01	-.585046E+00	-.143000E-03	.573527E+00	.115776E+01	-.561506E+03	.674756E+00
19	.298749E+00	.549068E-04	.206184E+01	-.576524E+00	-.143000E-03	.573517E+00	.115289E+01	-.521296E+03	.679454E+00
20	.352281E+00	.642528E-04	.241280E+01	-.567650E+00	-.143000E-03	.573506E+00	.114782E+01	-.620644E+03	.684427E+00
21	.407621E+00	.739118E-04	.277551E+01	-.554449E+00	-.143000E-03	.573495E+00	.114029E+01	-.955963E+03	.691766E+00
22	.463998E+00	.837517E-04	.314502E+01	-.533944E+00	-.143000E-03	.573484E+00	.112861E+01	-.145275E+04	.703165E+00
23	.501774E+00	.903466E-04	.339267E+01	-.517250E+00	-.143000E-03	.573476E+00	.111911E+01	-.121688E+04	.712446E+00
24	.539432E+00	.969234E-04	.363964E+01	-.507553E+00	-.214000E-03	.573469E+00	.111359E+01	-.516924E+03	.717937E+00
25	.576748E+00	.103444E-03	.388451E+01	-.500761E+00	-.288000E-03	.573462E+00	.110973E+01	-.100445E+04	.721612E+00
26	.613504E+00	.109872E-03	.412589E+01	-.483115E+00	-.370000E-03	.573455E+00	.109970E+01	-.193335E+04	.731423E+00
27	.649494E+00	.116173E-03	.436250E+01	-.459637E+00	-.490000E-03	.573448E+00	.108636E+01	-.229901E+04	.744475E+00
28	.684532E+00	.122316E-03	.459317E+01	-.431985E+00	-.610000E-03	.573441E+00	.107065E+01	-.299804E+04	.759847E+00
29	.718449E+00	.128273E-03	.481688E+01	-.397567E+00	-.755000E-03	.573435E+00	.105109E+01	-.364230E+04	.776981E+00
30	.751095E+00	.134021E-03	.503273E+01	-.356842E+00	-.930000E-03	.573429E+00	.102792E+01	-.448781E+04	.801622E+00
31	.782338E+00	.139539E-03	.523994E+01	-.308019E+00	-.109000E-02	.573423E+00	.100007E+01	-.566660E+04	.828763E+00
32	.812079E+00	.144812E-03	.543794E+01	-.248325E+00	-.121500E-02	.573418E+00	.965829E+00	-.749938E+04	.861949E+00
33	.840282E+00	.149834E-03	.562654E+01	-.173212E+00	-.130000E-02	.573413E+00	.922343E+00	-.984682E+04	.903706E+00
34	.866977E+00	.154608E-03	.580579E+01	-.874130E-01	-.138000E-02	.573409E+00	.871881E+00	-.108645E+05	.951405E+00
35	.892125E+00	.159114E-03	.597501E+01	-.939380E-02	-.145000E-02	.573405E+00	.824996E+00	-.961344E+04	.994776E+00

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36	.915465E+00	.163295E-03	.613201E+01	.495206E-01	-.147700E-02	.573402E+00	.788777E+00	-.780099E+04	.102753E+01
37	.936603E+00	.167075E-03	.627395E+01	.929984E-01	-.147700E-02	.573399E+00	.761501E+00	-.674625E+04	.105170E+01
38	.955166E+00	.170386E-03	.639829E+01	.126630E+00	-.147700E-02	.573396E+00	.740033E+00	-.626886E+04	.107040E+01
39	.970838E+00	.173175E-03	.650303E+01	.154234E+00	-.147700E-02	.573394E+00	.722142E+00	-.684450E+04	.108574E+01
40	.983359E+00	.175399E-03	.658654E+01	.178401E+00	-.147700E-02	.573393E+00	.706260E+00	-.716831E+04	.109918E+01
41	.992517E+00	.177022E-03	.664750E+01	.202789E+00	-.147700E-02	.573392E+00	.690007E+00	-.158768E+05	.111274E+01
42	.998144E+00	.178019E-03	.668491E+01	.234122E+00	-.147700E-02	.573391E+00	.668760E+00	-.267840E+05	.113016E+01

0NZ = 1 X/C = 0.

0 IT	VWALL	DELVW	TWALL	DELTW
1	.140234E+03	.965506E+03	.140234E+03	.169458E+04
2	.110574E+04	-.375942E+03	.183481E+04	-.455513E+03
3	.729798E+03	-.121338E+03	.137930E+04	-.873220E+02
4	.608461E+03	-.131402E+02	.129198E+04	-.508007E+01
5	.595321E+03	-.119181E+00	.128689E+04	-.240102E-01
6	.595201E+03	-.691029E-05	.128687E+04	-.739189E-06

0 IT	VWALL	DELVW	TWALL	DELTW
1	.595201E+03	.818802E+01	.128687E+04	.418003E+02
2	.603389E+03	-.105973E+01	.132867E+04	-.513149E+01
3	.602330E+03	-.799914E-02	.132354E+04	-.211865E-01
4	.602322E+03	.885071E-03	.132352E+04	.298144E-02
5	.602322E+03	-.148656E-05	.132352E+04	-.163561E-04

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.602322E+03	0.	0.	.132352E+04	.104062E+01	0.
4	.000197	.116879E-04	.118607E+00	.601126E+03	.241525E-04	.238632E+00	.109972E+04	.104014E+01	.361757E-04
7	.000425	.543147E-04	.254853E+00	.591755E+03	.104914E-03	.461308E+00	.856337E+03	.103841E+01	.780100E-04
10	.000689	.141928E-03	.407615E+00	.561861E+03	.253445E-03	.654159E+00	.611081E+03	.103494E+01	.126318E-03
13	.000995	.291809E-03	.570140E+00	.496822E+03	.478029E-03	.805201E+00	.387053E+03	.102939E+01	.181996E-03
16	.001349	.522390E-03	.727495E+00	.388786E+03	.782843E-03	.909307E+00	.207727E+03	.102198E+01	.246042E-03
19	.001758	.848895E-03	.859327E+00	.250983E+03	.116829E-02	.966479E+00	.881434E+02	.101387E+01	.319613E-03
22	.002232	.127856E-02	.944794E+00	.121274E+03	.163354E-02	.991554E+00	.265217E+02	.100692E+01	.404140E-03
25	.002781	.181028E-02	.985824E+00	.384563E+02	.218031E-02	.998849E+00	.465099E+01	.100251E+01	.501438E-03
28	.003417	.244153E-02	.998018E+00	.659694E+01	.281551E-02	.999979E+00	.264342E+00	.100059E+01	.613727E-03
31	.004152	.317660E-02	.999889E+00	.449703E+00	.355112E-02	.100000E+01	-.249870E-01	.100007E+01	.743570E-03
34	.005004	.402813E-02	.999999E+00	.664897E-02	.440268E-02	.100000E+01	-.212152E-02	.100000E+01	.893645E-03
37	.005990	.501392E-02	.100000E+01	.190038E-05	.538847E-02	.100000E+01	-.183130E-04	.100000E+01	.106780E-02
40	.007131	.615509E-02	.100000E+01	-.671485E-09	.652964E-02	.100000E+01	-.236484E-09	.100000E+01	.126918E-02
40	.007131	.615509E-02	.100000E+01	-.671485E-09	.652964E-02	.100000E+01	-.236484E-09	.100000E+01	.126918E-02

0 BOUNDARY-LAYER PARAMETERS
0 DELSTX = .183019E-03 DELSTZ = .116924E-03 THETAX = .678753E-04 THETAZ = .475548E-04
CFX = .560245E-02 CFZ = 0. HX = .269640E+01 HZ = .245872E+01

0 FLOW PARAMETERS
0 UE = .592725E+03 WE = 0. PE = .924951E+03 TE = .619353E+03
0 RHOE = .870288E-03 MUE = .427765E-06 BLP = 0. SQUIG = 0.
0 TW = .644512E+03 RHOW = .836315E-03 VW = 0. CW = .989668E+00

ONZ = 2 X/C = .700000E-04

O IT	VWALL	DELVW	TWALL	DELTW
1	.602322E+03	-.834872E+02	.132352E+04	-.234494E+03
2	.518835E+03	-.218364E+01	.108903E+04	-.341264E+01
3	.516652E+03	.103177E+00	.108561E+04	.385993E+00
4	.516755E+03	.404534E-02	.108600E+04	.163136E-01
5	.516759E+03	-.526982E-04	.108602E+04	-.165112E-03

O IT	VWALL	DELVW	TWALL	DELTW
1	.516759E+03	-.223285E-05	.108602E+04	-.514408E-05

O J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.516759E+03	0.	0.	.108602E+04	.104183E+01	0.
4	.000197	.100287E-04	.101779E+00	.516104E+03	.200683E-04	.199397E+00	.938317E+03	.104143E+01	.362632E-04
7	.000425	.466341E-04	.219024E+00	.510960E+03	.884260E-04	.394418E+00	.773090E+03	.104003E+01	.782068E-04
10	.000689	.122106E-03	.351985E+00	.494108E+03	.217306E-03	.574903E+00	.596954E+03	.103725E+01	.126665E-03
13	.000995	.252216E-03	.497612E+00	.455605E+03	.417918E-03	.729811E+00	.421677E+03	.103274E+01	.182564E-03
16	.001349	.455395E-03	.647176E+00	.386314E+03	.698837E-03	.849732E+00	.263405E+03	.102644E+01	.246935E-03
19	.001758	.750011E-03	.785245E+00	.286197E+03	.106495E-02	.930310E+00	.138739E+03	.101898E+01	.320945E-03
22	.002232	.114991E-02	.893468E+00	.172968E+03	.151799E-02	.974869E+00	.575740E+02	.101135E+01	.405978E-03
25	.002781	.166034E-02	.960404E+00	.779546E+02	.205918E-02	.993679E+00	.170130E+02	.100541E+01	.503753E-03
28	.003417	.228221E-02	.990172E+00	.232726E+02	.269274E-02	.999099E+00	.301592E+01	.100189E+01	.616410E-03
31	.004152	.301446E-02	.998616E+00	.390621E+01	.342812E-02	.999969E+00	.203074E+00	.100043E+01	.746513E-03
34	.005004	.386558E-02	.999914E+00	.286729E+00	.427968E-02	.100000E+01	-.115251E-01	.100006E+01	.896998E-03
37	.005990	.485134E-02	.999999E+00	.578321E-02	.526546E-02	.100000E+01	-.142243E-02	.100000E+01	.107117E-02
40	.007131	.599250E-02	.100000E+01	.846918E-05	.640663E-02	.100000E+01	-.150138E-04	.100000E+01	.127280E-02
43	.008452	.731355E-02	.100000E+01	.146354E-08	.772768E-02	.100000E+01	.153762E-08	.100000E+01	.150620E-02
43	.008452	.731355E-02	.100000E+01	.146354E-08	.772768E-02	.100000E+01	.153762E-08	.100000E+01	.150620E-02

O BOUNDARY-LAYER PARAMETERS

O DELSTX = .214026E-03 DELSTZ = .140857E-03 THETAX = .794240E-04 THETAZ = .571248E-04

CFX = .481108E-02 CFZ = .587326E-01 HX = .269472E+01 HZ = .246577E+01

O FLOW PARAMETERS

O UE = .592725E+03 WE = .102039E+03 PE = .920429E+03 TE = .618487E+03

O RHOE = .867247E-03 MUE = .427320E-06 BLP = 0. SQUIG = 0.

O TW = .644355E+03 RHOW = .832430E-03 VW = 0. CW = .989376E+00

NZ= 2 NP= 43 DESTZ= .1408567179553E-03 RDSTZ= .2916975169257E+02

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.83101	-.44096	0.	2.2971	-.75691E-03	1.0418	-.52662E-05	-.12035E-01
2	.81674E-01	.66406E-01	.79511	-.43950	.18760	2.2969	-.31471E-02	1.0418	-.97457E-03	-.11868E-01
3	.16742	.13297	.75754	-.43677	.38455	2.2962	-.11287E-01	1.0417	-.19845E-02	-.11688E-01
4	.25745	.19940	.71842	-.43244	.59122	2.2945	-.26538E-01	1.0414	-.30278E-02	-.11490E-01
5	.35195	.26536	.67784	-.42638	.80793	2.2909	-.49531E-01	1.0411	-.41028E-02	-.11260E-01

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6	.45113	.33049	.63594	-.41845	1.0349	2.2845	-.80839E-01	1.0406	-.52059E-02	-.10983E-01
7	.55522	.39442	.59290	-.40851	1.2723	2.2740	-.12091	1.0400	-.63312E-02	-.10639E-01
8	.66445	.45674	.54894	-.39646	1.5199	2.2581	-.17000	1.0393	-.74697E-02	-.10207E-01
9	.77904	.51704	.50432	-.38220	1.7776	2.2353	-.22807	1.0384	-.86082E-02	-.96631E-02
10	.89925	.57490	.45937	-.36569	2.0446	2.2039	-.29466	1.0372	-.97289E-02	-.89841E-02
11	1.0253	.62991	.41445	-.34694	2.3201	2.1620	-.36878	1.0360	-.10809E-01	-.81482E-02
12	1.1575	.68167	.36997	-.32602	2.6027	2.1080	-.44875	1.0345	-.11919E-01	-.71384E-02
13	1.2961	.72981	.32638	-.30307	2.8905	2.0400	-.53215	1.0327	-.12726E-01	-.59465E-02
14	1.4414	.77402	.28415	-.27833	3.1813	1.9567	-.61570	1.0308	-.13490E-01	-.45774E-02
15	1.5936	.81406	.24378	-.25213	3.4720	1.8569	-.69531	1.0287	-.14071E-01	-.30534E-02
16	1.7531	.84973	.20573	-.22489	3.7593	1.7403	-.76622	1.0264	-.14429E-01	-.14174E-02
17	1.9202	.88097	.17048	-.19712	4.0394	1.6075	-.82330	1.0240	-.14524E-01	.26586E-03
18	2.0952	.90779	.13840	-.16942	4.3082	1.4601	-.86149	1.0215	-.14333E-01	.19123E-02
19	2.2785	.93031	.10932	-.14242	4.5613	1.3008	-.87641	1.0189	-.13844E-01	.34255E-02
20	2.4705	.94877	.84937E-01	-.11677	4.7949	1.1336	-.86509	1.0163	-.13063E-01	.47073E-02
21	2.6716	.96349	.63838E-01	-.93087E-01	5.0054	.96354	-.82657	1.0138	-.12020E-01	.56724E-02
22	2.8822	.97497	.46463E-01	-.71900E-01	5.1900	.79621	-.76242	1.0113	-.10763E-01	.62621E-02
23	3.1029	.98337	.32618E-01	-.53596E-01	5.3471	.63742	-.67698	1.0091	-.93599E-02	.64556E-02
24	3.3340	.98948	.21985E-01	-.38387E-01	5.4764	.49253	-.57649	1.0071	-.78884E-02	.62742E-02
25	3.5764	.99368	.14151E-01	-.26282E-01	5.5788	.36584	-.46928	1.0054	-.64282E-02	.57779E-02
26	3.8304	.99643	.86408E-02	-.17100E-01	5.6566	.26004	-.36367	1.0040	-.50524E-02	.50543E-02
27	4.0967	.99812	.49650E-02	-.10499E-01	5.7130	.17603	-.26709	1.0028	-.38194E-02	.42035E-02
28	4.3761	.99910	.26557E-02	-.60314E-02	5.7517	.11298	-.18499	1.0019	-.27681E-02	.33221E-02
29	4.6693	.99962	.13014E-02	-.32082E-02	5.7769	.68148E-01	-.12016	1.0012	-.19160E-02	.24909E-02
30	4.9769	.99987	.54915E-03	-.15527E-02	5.7921	.38479E-01	-.72732E-01	1.0007	-.12611E-02	.17669E-02
31	5.2998	.99997	.20735E-03	-.68841E-03	5.8008	.20162E-01	-.40725E-01	1.0004	-.78519E-03	.11810E-02
32	5.6387	1.0000	.46445E-04	-.26105E-03	5.8053	.97166E-02	-.20913E-01	1.0002	-.45967E-03	.73987E-03
33	5.9946	1.0000	0.	0.	5.8074	.42612E-02	-.97494E-02	1.0001	-.25124E-03	.43165E-03
34	6.3682	1.0000	0.	0.	5.8083	.16790E-02	-.40747E-02	1.0001	-.12715E-03	.23267E-03
35	6.7604	1.0000	0.	0.	5.8087	.58501E-03	-.15032E-02	1.0000	-.59002E-04	.11478E-03
36	7.1723	1.0000	0.	0.	5.8088	.17666E-03	-.47982E-03	1.0000	-.24816E-04	.51233E-04
37	7.6047	1.0000	0.	0.	5.8088	.45010E-04	-.12904E-03	1.0000	-.93274E-05	.20400E-04
38	8.0588	1.0000	0.	0.	5.8088	.93208E-05	-.28165E-04	1.0000	-.30795E-05	.71197E-05
39	8.5355	1.0000	0.	0.	5.8088	.14826E-05	-.47159E-05	1.0000	-.87494E-06	.21283E-05
40	9.0361	1.0000	0.	0.	5.8088	.16454E-06	-.55015E-06	1.0000	-.17529E-06	.66698E-06
41	9.5617	1.0000	0.	0.	5.8088	.10376E-07	-.36427E-07	1.0000	0.	0.
42	10.114	1.0000	0.	0.	5.8088	.16589E-09	-.57234E-09	1.0000	0.	0.
43	10.693	1.0000	0.	0.	5.8088	0.	0.	1.0000	0.	0.

ONZ = 3 X/C = .733400E-03

0 IT	VWALL	DELVW	TWALL	DELTW
1	.516759E+03	-.652296E+02	.108602E+04	-.123552E+03
2	.451529E+03	-.155202E+01	.962465E+03	-.216163E+01
3	.449977E+03	.931211E-01	.960303E+03	.350619E+00
4	.450070E+03	.254963E-02	.960654E+03	.994100E-02
5	.450073E+03	-.605717E-04	.960664E+03	-.181933E-03

0 IT	VWALL	DELVW	TWALL	DELTW
1	.450073E+03	-.133565E-05	.960664E+03	-.263538E-05

0 J ETA F U V G W T TEMP-R Y-FT

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1	0.000000	0.	0.	.450073E+03	0.	0.	.960664E+03	.105038E+01	0.
4	.000197	.873495E-05	.886542E-01	.449662E+03	.178340E-04	.177566E+00	.842048E+03	.104985E+01	.368700E-04
7	.000425	.406318E-04	.190930E+00	.446554E+03	.790125E-04	.354410E+00	.709743E+03	.104810E+01	.795057E-04
10	.000689	.106509E-03	.307672E+00	.436491E+03	.195561E-03	.522874E+00	.568505E+03	.104497E+01	.128745E-03
13	.000995	.220606E-03	.437838E+00	.413223E+03	.379507E-03	.674250E+00	.425457E+03	.103996E+01	.185523E-03
16	.001349	.400516E-03	.575769E+00	.369465E+03	.641583E-03	.799985E+00	.290115E+03	.103334E+01	.250885E-03
19	.001758	.665823E-03	.714435E+00	.300428E+03	.989909E-03	.893709E+00	.173671E+03	.102535E+01	.326013E-03
22	.002232	.103482E-02	.835585E+00	.210367E+03	.142938E-02	.953761E+00	.864059E+02	.101690E+01	.412280E-03
25	.002781	.152000E-02	.924623E+00	.117579E+03	.196264E-02	.984851E+00	.329536E+02	.100939E+01	.511355E-03
28	.003417	.212565E-02	.974939E+00	.473621E+02	.259296E-02	.996739E+00	.850091E+01	.100407E+01	.625316E-03
31	.004152	.285163E-02	.994731E+00	.119986E+02	.332753E-02	.999658E+00	.118081E+01	.100126E+01	.756713E-03
34	.005004	.370114E-02	.999414E+00	.158472E+01	.417900E-02	.100000E+01	.334964E-01	.100024E+01	.908545E-03
37	.005990	.466672E-02	.999974E+00	.819234E-01	.516479E-02	.100000E+01	-.732062E-02	.100002E+01	.106422E-02
40	.007131	.582788E-02	.100000E+01	.957850E-03	.630596E-02	.100000E+01	-.405489E-03	.100000E+01	.128756E-02
43	.008452	.714593E-02	.100000E+01	.351106E-06	.762701E-02	.100000E+01	-.224253E-05	.100000E+01	.152295E-02
46	.009981	.867820E-02	.100000E+01	-.187196E-08	.915628E-02	.100000E+01	-.649475E-09	.100000E+01	.179544E-02
46	.009981	.867820E-02	.100000E+01	-.187196E-08	.915628E-02	.100000E+01	-.649475E-09	.100000E+01	.179544E-02

```
0  BOUNDARY-LAYER PARAMETERS
0  DELSTY =   .249117E-03   DELSTZ =   .163931E-03   THETAX =   .913808E-04   THETAZ =   .657528E-04
   CFX    =   .421706E-02   CFZ    =   .186664E-01   HX     =   .272614E+01   HZ     =   .249314E+01

0  FLOW PARAMETERS
0  UE     =   .592725E+03   WE     =   .285819E+03   PE     =   .889889E+03   TE     =   .612552E+03
0  RHOE   =   .846594E-03   MUE    =   .424266E-06   BLP    =  0.                SQUIG  =  0.
0  TW     =   .643411E+03   RHOW   =   .805990E-03   VW     =  0.                CW     =   .987319E+00
```

NZ= 3 NP= 46 DESTZ= .163930718880E-03 PDSTZ= .93494931212E+02

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.84139	-.46435	0.	.81752	-.16256E-03	1.0504	-.33375E-04	-.22005E-01
2	.71355E-01	.58860E-01	.80840	-.46224	.58333E-01	.81749	-.39387E-03	1.0503	-.15134E-02	-.20742E-01
3	.14627	.11812	.77390	-.45874	.11957	.81739	-.22287E-02	1.0502	-.30205E-02	-.19492E-01
4	.22491	.17757	.73803	-.45349	.18385	.81707	-.60422E-02	1.0499	-.45042E-02	-.18242E-01
5	.30746	.23694	.70088	-.44648	.25127	.81632	-.12003E-01	1.0494	-.59587E-02	-.16997E-01
6	.39409	.29599	.66258	-.43771	.32195	.81493	-.20273E-01	1.0488	-.73773E-02	-.15755E-01
7	.48500	.35441	.62327	-.42720	.39595	.81260	-.30996E-01	1.0481	-.87531E-02	-.14514E-01
8	.58037	.41191	.58311	-.41497	.47331	.80901	-.44288E-01	1.0472	-.10078E-01	-.13270E-01
9	.68042	.46818	.54229	-.40105	.55403	.80378	-.60221E-01	1.0461	-.11343E-01	-.12015E-01
10	.78536	.52287	.50102	-.38550	.63804	.79648	-.78804E-01	1.0449	-.12537E-01	-.10740E-01
11	.89540	.57567	.45954	-.36836	.72521	.78665	-.99953E-01	1.0434	-.13647E-01	-.94332E-02
12	1.0109	.62624	.41812	-.34968	.81530	.77376	-.12347	1.0418	-.14657E-01	-.80822E-02
13	1.1317	.67425	.37705	-.32956	.90798	.75728	-.14900	1.0400	-.15550E-01	-.66765E-02
14	1.2595	.71939	.33664	-.30806	1.0028	.73669	-.17600	1.0379	-.16303E-01	-.52083E-02

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15	1.3913	.76139	.29723	-.28532	1.0991	.71147	-.20371	1.0357	-.16893E-01	-.36762E-02
16	1.5304	.79999	.25919	-.26149	1.1961	.68121	-.23115	1.0333	-.17294E-01	-.20877E-02
17	1.6762	.83499	.22787	-.23678	1.2929	.64563	-.25707	1.0308	-.17480E-01	-.46268E-03
18	1.8289	.86625	.18866	-.21146	1.3885	.60464	-.28002	1.0281	-.17426E-01	.11647E-02
19	1.9887	.89371	.15690	-.18586	1.4816	.55840	-.29839	1.0253	-.17114E-01	.27451E-02
20	2.1561	.91737	.12791	-.16040	1.5709	.50743	-.31058	1.0225	-.16531E-01	.42153E-02
21	2.3314	.93733	.10197	-.13556	1.6551	.45259	-.31513	1.0197	-.15679E-01	.55035E-02
22	2.5150	.95376	.79268E-01	-.11186	1.7328	.39513	-.31096	1.0169	-.14574E-01	.65367E-02
23	2.7072	.96693	.59887E-01	-.89808E-01	1.8030	.33665	-.29759	1.0142	-.13249E-01	.72518E-02
24	2.9085	.97717	.43813E-01	-.69892E-01	1.8648	.27898	-.27537	1.0117	-.11754E-01	.76064E-02
25	3.1193	.98495	.30909E-01	-.52501E-01	1.9175	.22406	-.24554	1.0094	-.10152E-01	.75888E-02
26	3.3403	.99040	.20924E-01	-.37884E-01	1.9610	.17371	-.21019	1.0073	-.85156E-02	.72228E-02
27	3.5718	.99423	.13515E-01	-.26118E-01	1.9956	.12946	-.17204	1.0056	-.69194E-02	.65657E-02
28	3.8145	.99674	.82711E-02	-.17093E-01	2.0219	.92318E-01	-.13405	1.0041	-.54308E-02	.57006E-02
29	4.0690	.99829	.47553E-02	-.10535E-01	2.0411	.62669E-01	-.98942E-01	1.0029	-.41042E-02	.47234E-02
30	4.3360	.99918	.25399E-02	-.60624E-02	2.0543	.40276E-01	-.69823E-01	1.0019	-.29761E-02	.37287E-02
31	4.6161	.99966	.12399E-02	-.32207E-02	2.0629	.24357E-01	-.44852E-01	1.0013	-.20622E-02	.27972E-02
32	4.9100	.99088	.53948E-03	-.15526E-02	2.0681	.13768E-01	-.27209E-01	1.0008	-.13591E-02	.19671E-02
33	5.2184	.99998	.18971E-03	-.70861E-03	2.0710	.72183E-02	-.15253E-01	1.0004	-.84741E-03	.13306E-02
34	5.5423	1.0000	.38404E-04	-.22594E-03	2.0726	.34801E-02	-.78356E-02	1.0002	-.49675E-03	.83519E-03
35	5.8822	1.0000	0.	0.	2.0733	.15274E-02	-.36526E-02	1.0001	-.27183E-03	.48806E-03
36	6.2391	1.0000	0.	0.	2.0736	.60301E-03	-.15272E-02	1.0001	-.13772E-03	.26343E-03
37	6.6139	1.0000	0.	0.	2.0737	.21105E-03	-.56462E-03	1.0000	-.53985E-04	.13009E-03
38	7.0073	1.0000	0.	0.	2.0738	.64307E-04	-.18129E-03	1.0000	-.26954E-04	.58131E-04
39	7.4205	1.0000	0.	0.	2.0738	.16657E-04	-.49380E-04	1.0000	-.10156E-04	.23187E-04
40	7.8543	1.0000	0.	0.	2.0738	.35505E-05	-.11047E-04	1.0000	-.33663E-05	.81186E-05
41	8.3097	1.0000	0.	0.	2.0738	.59375E-06	-.19357E-05	1.0000	-.96111E-06	.24422E-05
42	8.7880	1.0000	0.	0.	2.0738	.72077E-07	-.24584E-06	1.0000	-.23046E-06	.61321E-06
43	9.2902	1.0000	0.	0.	2.0738	.54553E-08	-.19490E-07	1.0000	-.39182E-07	.14862E-06
44	9.8175	1.0000	0.	0.	2.0738	.16237E-09	-.58659E-09	1.0000	-.35184E-15	.22518E-13
45	10.371	1.0000	0.	0.	2.0738	-.12157E-14	0.	1.0000	-.60767E-15	.19452E-13
46	10.952	1.0000	0.	0.	2.0738	0.	0.	1.0000	0.	0.

ONZ = 4 X/C = .186860E-02

O IT	VWALL	DELVW	TWALL	DELTW
1	.450073E+03	-.169930E+02	.950664E+03	-.150104E+02
2	.433080E+03	-.350252E+00	.945653E+03	-.113608E+01
3	.432730E+03	.270481E-01	.944517E+03	.112943E+00
4	.432757E+03	.283414E-03	.944630E+03	.468675E-03
5	.432757E+03	-.283936E-04	.944631E+03	-.714626E-04

O J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.432757E+03	0.	0.	.944631E+03	.106697E+01	0.
4	.000197	.839881E-05	.852423E-01	.432355E+03	.175494E-04	.174787E+00	.829769E+03	.106606E+01	.380530E-04
7	.000425	.390689E-04	.183595E+00	.429521E+03	.778069E-04	.349225E+00	.700745E+03	.106313E+01	.820247E-04
10	.000689	.102426E-03	.295954E+00	.420459E+03	.192707E-03	.515674E+00	.562111E+03	.105804E+01	.132735E-03
13	.000995	.212226E-03	.421547E+00	.399535E+03	.374195E-03	.665487E+00	.421635E+03	.105090E+01	.191095E-03
16	.001349	.385605E-03	.556374E+00	.360224E+03	.633002E-03	.790445E+00	.289605E+03	.104174E+01	.258129E-03
19	.001759	.641980E-03	.691649E+00	.298205E+03	.977492E-03	.894741E+00	.176846E+03	.103150E+01	.335007E-03
22	.002232	.100026E-02	.813778E+00	.216507E+03	.141318E-02	.946939E+00	.918702E+02	.102116E+01	.423112E-03

25	.002781	.147477E-02	.907985E+00	.129361E+03	.194352E-02	.981003E+00	.379212E+02	.101212E+01	.524132E-03
28	.003417	.207226E-02	.965853E+00	.581797E+02	.257224E-02	.995321E+00	.111363E+02	.100559E+01	.640175E-03
31	.004152	.279383E-02	.991576E+00	.173605E+02	.330626E-02	.999398E+00	.189535E+01	.100191E+01	.773836E-03
34	.005004	.364208E-02	.998842E+00	.286816E+01	.415765E-02	.999995E+00	.954535E-01	.100043E+01	.928182E-03
37	.005990	.462744E-02	.999932E+00	.199681E+00	.514344E-02	.100000E+01	-.114219E-01	.100005E+01	.110671E-02
40	.007131	.576855E-02	.999999E+00	.361834E-02	.628461E-02	.100000E+01	-.101071E-02	.100000E+01	.131334E-02
43	.008452	.708963E-02	.100000E+01	.454622E-05	.760566E-02	.100000E+01	-.122356E-04	.100000E+01	.155253E-02
46	.009981	.861891E-02	.100000E+01	.197186E-08	.913494E-02	.100000E+01	-.347535E-08	.100000E+01	.182943E-02
46	.009981	.861891E-02	.100000E+01	.197186E-08	.913494E-02	.100000E+01	-.347535E-08	.100000E+01	.182943E-02

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0  BOUNDARY-LAYER PARAMETERS
0  DELSTX =   .268848E-03   DELSTZ =   .175413E-03   THETAX =   .974888E-04   THETAZ =   .689869E-04
   CFX    =   .410414E-02   CFZ    =   .114503E-01   HX     =   .275773E+01   HZ     =   .254270E+01

0  FLOW PARAMETERS
0  UE     =   .592725E+03   WE     =   .463744E+03   PE     =   .834703E+03   TE     =   .601450E+03
0  RHOE   =   .808752E-03   MUE    =   .418512E-06   BLP    =  0.                SQUIG  =  0.
0  TW     =   .641730E+03   RHOW   =   .757988E-03   VW     =  0.                CW     =   .983430E+00
```

NZ= 4 NP= 46 DESTZ= .1754133098952E-03 RDSTZ= .1571983962824E+03

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.85765	-.48207	0.	.50222	-.11980E-03	1.0670	-.87730E-04	-.42354E-01
2	.68831E-01	.57897E-01	.82464	-.47966	.34569E-01	.50224	.24092E-03	1.0669	-.27662E-02	-.38913E-01
3	.14109	.11623	.79010	-.47618	.70861E-01	.50223	-.35568E-03	1.0666	-.54553E-02	-.35517E-01
4	.21693	.17479	.75417	-.47135	.10895	.50214	-.21281E-02	1.0661	-.80210E-02	-.32141E-01
5	.29652	.23332	.71691	-.46502	.14891	.50185	-.51992E-02	1.0653	-.10446E-01	-.28805E-01
6	.38002	.29156	.67841	-.45704	.19079	.50122	-.96894E-02	1.0643	-.12715E-01	-.25527E-01
7	.46761	.34922	.63881	-.44730	.23466	.50011	-.15710E-01	1.0631	-.14811E-01	-.22330E-01
8	.55946	.40601	.59826	-.43566	.28053	.49832	-.23355E-01	1.0617	-.16719E-01	-.19231E-01
9	.65576	.46160	.55696	-.42207	.32841	.49562	-.32685E-01	1.0600	-.18427E-01	-.16247E-01
10	.75670	.51567	.51514	-.40647	.37827	.49176	-.43717E-01	1.0580	-.19923E-01	-.13391E-01
11	.86248	.56789	.47308	-.38889	.43004	.48647	-.56407E-01	1.0559	-.21196E-01	-.10674E-01
12	.97331	.61793	.43106	-.36938	.48361	.47943	-.70630E-01	1.0534	-.22236E-01	-.80991E-02
13	1.0894	.66549	.38941	-.34808	.53879	.47033	-.86164E-01	1.0508	-.23035E-01	-.56681E-02
14	1.2110	.71026	.34848	-.32516	.59534	.45885	-.10267	1.0480	-.23585E-01	-.33785E-02
15	1.3383	.75199	.30864	-.30086	.65292	.44470	-.11969	1.0449	-.23979E-01	-.12268E-02
16	1.4715	.79045	.27023	-.27548	.71112	.42762	-.13663	1.0417	-.23908E-01	.78834E-03
17	1.6110	.82546	.23363	-.24933	.76944	.40743	-.15278	1.0384	-.23667E-01	.26637E-02
18	1.7570	.85691	.19917	-.22280	.82729	.38406	-.16731	1.0350	-.23152E-01	.43879E-02
19	1.9098	.88474	.16715	-.19628	.88402	.35758	-.17936	1.0315	-.22363E-01	.59396E-02
20	2.0697	.90896	.13786	-.17019	.93889	.32821	-.18804	1.0280	-.21306E-01	.72873E-02
21	2.2370	.92964	.11150	-.14494	.99117	.29637	-.19257	1.0245	-.19994E-01	.83913E-02
22	2.4121	.94694	.88217E-01	-.12097	1.0401	.26268	-.19231	1.0212	-.18454E-01	.92095E-02

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23	2.5953	.96107	.68092E-01	-.98669E-01	1.0850	.22793	-.18693	1.0179	-.16721E-01	.97040E-02
24	2.7871	.97232	.51110E-01	-.78402E-01	1.1253	.19308	-.17644	1.0149	-.14845E-01	.98505E-02
25	2.9880	.98100	.37165E-01	-.60466E-01	1.1605	.15917	-.16127	1.0121	-.12887E-01	.96456E-02
26	3.1983	.98748	.26067E-01	-.45069E-01	1.1904	.12725	-.14229	1.0096	-.10915E-01	.91123E-02
27	3.4186	.99213	.17543E-01	-.32304E-01	1.2150	.98268E-01	-.12077	1.0074	-.89965E-02	.83004E-02
28	3.6495	.99532	.11258E-01	-.22140E-01	1.2345	.72991E-01	-.98187E-01	1.0056	-.71976E-02	.72823E-02
29	3.8915	.99740	.68342E-02	-.14413E-01	1.2493	.51898E-01	-.76125E-01	1.0041	-.55729E-02	.61442E-02
30	4.1453	.99867	.38846E-02	-.88333E-02	1.2600	.35134E-01	-.55990E-01	1.0028	-.41620E-02	.49746E-02
31	4.4115	.99939	.20383E-02	-.50393E-02	1.2674	.22513E-01	-.38842E-01	1.0019	-.29369E-02	.36548E-02
32	4.6908	.99976	.96636E-03	-.26376E-02	1.2721	.13564E-01	-.25250E-01	1.0012	-.20508E-02	.28490E-02
33	4.9838	.99993	.39839E-03	-.12386E-02	1.2750	.76264E-02	-.15269E-01	1.0007	-.13404E-02	.19995E-02
34	5.2914	.99999	.11453E-03	-.60712E-03	1.2766	.39682E-02	-.85174E-02	1.0004	-.82906E-03	.13254E-02
35	5.6143	1.0000	.94607E-05	-.49920E-04	1.2775	.18924E-02	-.43411E-02	1.0002	-.48200E-03	.82440E-03
36	5.9533	1.0000	0.	0.	1.2779	.81780E-03	-.19991E-02	1.0001	-.26134E-03	.47755E-03
37	6.3091	1.0000	0.	0.	1.2780	.31602E-03	-.82079E-03	1.0001	-.13093E-03	.25529E-03
38	6.6828	1.0000	0.	0.	1.2781	.10744E-03	-.29565E-03	1.0000	-.59962E-04	.12457E-03
39	7.0752	1.0000	0.	0.	1.2781	.31481E-04	-.91540E-04	1.0000	-.24782E-04	.54770E-04
40	7.4871	1.0000	0.	0.	1.2781	.77407E-05	-.23720E-04	1.0000	-.91004E-05	.21362E-04
41	7.9197	1.0000	0.	0.	1.2781	.15388E-05	-.49563E-05	1.0000	-.29124E-05	.72495E-05
42	8.3738	1.0000	0.	0.	1.2781	.23389E-06	-.78984E-06	1.0000	-.79206E-06	.20874E-05
43	8.8507	1.0000	0.	0.	1.2781	.24731E-07	-.87343E-07	1.0000	-.17686E-06	.49269E-06
44	9.3514	1.0000	0.	0.	1.2781	.14898E-08	-.54852E-08	1.0000	-.30838E-07	.90555E-07
45	9.8772	1.0000	0.	0.	1.2781	.24792E-10	-.87626E-10	1.0000	-.39089E-08	.11681E-07
46	10.429	1.0000	0.	0.	1.2781	.30247E-12	-.10958E-11	1.0000	-.31465E-09	.11399E-08

CNZ = 5 X/C = .352930E-02

0 IT	VWALL	DELVW	TWALL	DELTW
1	.432757E+03	.465832E+02	.944631E+03	-.116186E+02
2	.479340E+03	-.242779E+00	.933012E+03	-.109888E+01
3	.479097E+03	.216213E-01	.931913E+03	.784606E-01
4	.479119E+03	.400109E-03	.931992E+03	.520668E-03
5	.479119E+03	-.324336E-04	.931992E+03	-.590242E-04

0 IT	VWALL	DELVW	TWALL	DELTW
1	.479119E+03	.355446E-06	.931992E+03	.972914E-06

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.479119E+03	0.	0.	.931992E+03	.108860E+01	0.
4	.000197	.915004E-05	.922458E-01	.457417E+03	.172612E-04	.171711E+00	.811975E+03	.108714E+01	.395999E-04
7	.000425	.418709E-04	.193878E+00	.434026E+03	.763431E-04	.341990E+00	.682864E+03	.108265E+01	.853154E-04
10	.000689	.107877E-03	.305097E+00	.408525E+03	.188759E-03	.504284E+00	.549032E+03	.107512E+01	.137941E-03
13	.000995	.219728E-03	.425398E+00	.378263E+03	.366279E-03	.651253E+00	.416124E+03	.106490E+01	.198358E-03
16	.001349	.393081E-03	.552343E+00	.338252E+03	.619878E-03	.775624E+00	.291382E+03	.105270E+01	.267559E-03
19	.001758	.646135E-03	.679897E+00	.283269E+03	.958609E-03	.871726E+00	.183298E+03	.103955E+01	.346702E-03
22	.002232	.997605E-03	.797572E+00	.212620E+03	.138893E-02	.937418E+00	.996501E+02	.102677E+01	.437175E-03
25	.002781	.146319E-02	.892482E+00	.134955E+03	.191517E-02	.975443E+00	.442892E+02	.101579E+01	.540695E-03
28	.003417	.205232E-02	.955331E+00	.671226E+02	.254144E-02	.992943E+00	.147770E+02	.100773E+01	.659412E-03
31	.004152	.276839E-02	.986847E+00	.236140E+02	.327445E-02	.998751E+00	.319962E+01	.100294E+01	.795976E-03
34	.005004	.361432E-02	.997608E+00	.509740E+01	.412560E-02	.999921E+00	.318528E+00	.100079E+01	.953536E-03
37	.005990	.459913E-02	.999779E+00	.551973E+00	.511137E-02	.100000E+01	-.592597E-02	.100013E+01	.113569E-02
40	.007131	.574022E-02	.999992E+00	.223577E-01	.625254E-02	.100000E+01	-.269685E-02	.100001E+01	.134650E-02

43	.008452	.706126E-02	.100000E+01	.211637E-03	.757359E-02	.100000E+01	-.104504E-03	.100000E+01	.159051E-02
46	.009981	.859053E-02	.100000E+01	.153648E-06	.910286E-02	.100000E+01	-.583828E-06	.100000E+01	.187299E-02
49	.011752	.103609E-01	.100000E+01	-.238502E-08	.108732E-01	.100000E+01	.405243E-08	.100000E+01	.220000E-02
49	.011752	.103609E-01	.100000E+01	-.238502E-08	.108732E-01	.100000E+01	.405243E-08	.100000E+01	.220000E-02

```
0  BOUNDARY-LAYER PARAMETERS
0  DELSTX =  .286198E-03   DELSTZ =  .191563E-03   THETAX =  .105029E-03   THETAZ =  .736415E-04
   CFX    =  .461242E-02   CFZ    =  .865007E-02   HX     =  .272494E+01   HZ     =  .260130E+01

0  FLOW PARAMETERS
0  UE     =  .592724E+03   WE     =  .614794E+03   PE     =  .770661E+03   TE     =  .587887E+03
0  RHOE   =  .763927E-03   MUE    =  .411410E-06   BLP    = -.230398E+03   SQUIG  = -.306192E+00
0  TW     =  .639973E+03   RHOW   =  .701752E-03   VW     = -.731256E+00   CW     =  .978553E+00
```

NZ= 5 NP= 49 DESTZ= .1915633941432E-03 RDSTZ= .2186851056532E+03

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.88768	-.56691	0.	.44000	-.98810E-01	1.0886	-.18585E-03	-.75691E-01
2	.65600E-01	.57038E-01	.85128	-.55484	.28659E-01	.43374	-.95501E-01	1.0884	-.46506E-02	-.68060E-01
3	.13446	.11434	.81352	-.54197	.58299E-01	.42728	-.92076E-01	1.0880	-.90827E-02	-.60667E-01
4	.20672	.17171	.77486	-.52802	.88934E-01	.42076	-.88474E-01	1.0871	-.13207E-01	-.53491E-01
5	.28252	.22893	.73540	-.51306	.12058	.41419	-.84896E-01	1.0860	-.17000E-01	-.46577E-01
6	.36202	.28577	.69525	-.49717	.15323	.40757	-.81566E-01	1.0845	-.20440E-01	-.39963E-01
7	.44536	.34199	.65451	-.48041	.18692	.40089	-.78722E-01	1.0826	-.23509E-01	-.33684E-01
8	.53271	.39733	.61331	-.46283	.22164	.39411	-.76609E-01	1.0805	-.26193E-01	-.27768E-01
9	.62423	.45152	.57180	-.44445	.25738	.38715	-.75464E-01	1.0780	-.28481E-01	-.22235E-01
10	.72008	.50428	.53011	-.42525	.29414	.37991	-.75503E-01	1.0751	-.30366E-01	-.17101E-01
11	.82045	.55535	.48844	-.40521	.33190	.37226	-.76902E-01	1.0720	-.31845E-01	-.12377E-01
12	.92552	.60443	.44697	-.38428	.37058	.36403	-.79778E-01	1.0686	-.32919E-01	-.80676E-02
13	1.0355	.65125	.40592	-.36241	.41013	.35502	-.84167E-01	1.0649	-.33592E-01	-.41722E-02
14	1.1505	.69555	.36554	-.33959	.45041	.34500	-.90006E-01	1.0610	-.33872E-01	-.68735E-03
15	1.2709	.73708	.32610	-.31581	.49128	.33374	-.97112E-01	1.0569	-.33769E-01	.23945E-02
16	1.3967	.77562	.28790	-.29115	.53251	.32101	-.10518	1.0527	-.33299E-01	.50833E-02
17	1.5283	.81100	.25126	-.26572	.57385	.30660	-.11376	1.0484	-.32478E-01	.73903E-02
18	1.6660	.84306	.21647	-.23975	.61497	.29036	-.12229	1.0440	-.31327E-01	.93264E-02
19	1.8099	.87173	.18386	-.21350	.65549	.27220	-.13010	1.0396	-.29872E-01	.10901E-01
20	1.9603	.89697	.15371	-.18735	.69497	.25215	-.13649	1.0352	-.28140E-01	.12118E-01
21	2.1176	.91884	.12625	-.16168	.73295	.23034	-.14073	1.0309	-.26166E-01	.12981E-01
22	2.2821	.93742	.10169	-.13696	.76894	.20707	-.14219	1.0268	-.23989E-01	.13488E-01
23	2.4542	.95289	.80132E-01	-.11361	.80246	.18276	-.14038	1.0228	-.21655E-01	.13637E-01
24	2.6342	.96547	.61622E-01	-.92066E-01	.83309	.15797	-.13507	1.0192	-.19219E-01	.13435E-01
25	2.8225	.97544	.46108E-01	-.72673E-01	.86044	.13336	-.12630	1.0159	-.16740E-01	.12894E-01
26	3.0197	.98312	.33455E-01	-.55698E-01	.88428	.10963	-.11446	1.0127	-.14281E-01	.12046E-01
27	3.2261	.98884	.23445E-01	-.41295E-01	.90447	.87471E-01	-.10022	1.0100	-.11909E-01	.10938E-01

ORIGINAL PAGE IS
OF POOR QUALITY

28	3.4423	.99294	.15794E-01	-.29485E-01	.92104	.67503E-01	-.84507E-01	1.0077	-.96851E-02	.96385E-02
29	3.6688	.99576	.10171E-01	-.20168E-01	.93416	.50188E-01	-.68373E-01	1.0058	-.76619E-02	.82251E-02
30	3.9062	.99761	.62168E-02	-.13138E-01	.94415	.35796E-01	-.52866E-01	1.0042	-.58802E-02	.67834E-02
31	4.1552	.99875	.35742E-02	-.80922E-02	.95142	.24375E-01	-.38887E-01	1.0029	-.43645E-02	.53935E-02
32	4.4163	.99941	.19085E-02	-.46662E-02	.95646	.15763E-01	-.27075E-01	1.0020	-.31222E-02	.41224E-02
33	4.6902	.99976	.92877E-03	-.24871E-02	.95976	.96252E-02	-.17741E-01	1.0013	-.21441E-02	.30187E-02
34	4.9777	.99992	.39878E-03	-.12003E-02	.96180	.55131E-02	-.10870E-01	1.0008	-.14071E-02	.21090E-02
35	5.2794	.99999	.13248E-03	-.56497E-03	.96296	.29407E-02	-.61824E-02	1.0005	-.87795E-03	.13986E-02
36	5.5961	1.0000	.22029E-04	-.13251E-03	.96359	.14490E-02	-.32377E-02	1.0003	-.51780E-03	.87571E-03
37	5.9286	1.0000	0.	0.	.96389	.65355E-03	-.15469E-02	1.0001	-.28670E-03	.51439E-03
38	6.2776	1.0000	0.	0.	.96402	.26710E-03	-.66725E-03	1.0001	-.14784E-03	.28118E-03
39	6.6442	1.0000	0.	0.	.96408	.97759E-04	-.25679E-03	1.0000	-.70351E-04	.14167E-03
40	7.0290	1.0000	0.	0.	.96409	.31616E-04	-.86966E-04	1.0000	-.30568E-04	.65084E-04
41	7.4330	1.0000	0.	0.	.96410	.88932E-05	-.25506E-04	1.0000	-.11980E-04	.26920E-04
42	7.8573	1.0000	0.	0.	.96410	.21346E-05	-.63542E-05	1.0000	-.41744E-05	.98771E-05
43	8.3028	1.0000	0.	0.	.96410	.42688E-06	-.13127E-05	1.0000	-.12710E-05	.31577E-05
44	8.7706	1.0000	0.	0.	.96410	.68894E-07	-.21790E-06	1.0000	-.33131E-06	.86024E-06
45	9.2617	1.0000	0.	0.	.96410	.85667E-08	-.27761E-07	1.0000	-.72496E-07	.19369E-06
46	9.7774	1.0000	0.	0.	.96410	.75866E-09	-.25201E-08	1.0000	-.11551E-07	.42665E-07
47	10.319	1.0000	0.	0.	.96410	.39110E-10	-.13754E-09	1.0000	-.32487E-15	.20792E-13
48	10.887	1.0000	0.	0.	.96410	.22451E-14	.35921E-13	1.0000	-.56127E-15	.17961E-13
49	11.484	1.0000	0.	0.	.96410	0.	0.	1.0000	0.	0.

ONZ = 6 Y/C = .580450E-02

0 IT	VWALL	DELVW	TWALL	DELTW
1	.479119E+03	.270947E+01	.931992E+03	-.741041E+02
2	.481829E+03	-.526299E+00	.857888E+03	-.167334E+01
3	.481302E+03	.689392E-01	.856215E+03	.181934E+00
4	.481371E+03	.163417E-02	.856397E+03	.337403E-02
5	.481373E+03	-.791768E-04	.856400E+03	-.146933E-03

0 IT	VWALL	DELVW	TWALL	DELTW
1	.481373E+03	-.459035E-06	.856400E+03	-.628079E-08

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.481373E+03	0.	0.	.856400E+03	.111142E+01	0.
4	.000197	.919248E-05	.926634E-01	.459204E+03	.159392E-04	.158898E+00	.757125E+03	.110966E+01	.412501E-04
7	.000425	.420339E-04	.194420E+00	.432904E+03	.708637E-04	.319023E+00	.647971E+03	.110419E+01	.888459E-04
10	.000689	.108074E-03	.304575E+00	.401329E+03	.176228E-03	.474517E+00	.531604E+03	.109492E+01	.143574E-03
13	.000995	.219305E-03	.421536E+00	.363874E+03	.344091E-03	.618485E+00	.413139E+03	.108227E+01	.206293E-03
16	.001349	.390273E-03	.542513E+00	.319809E+03	.586177E-03	.743894E+00	.299431E+03	.106719E+01	.277966E-03
19	.001758	.637793E-03	.662881E+00	.267732E+03	.912818E-03	.844827E+00	.197946E+03	.105101E+01	.359720E-03
22	.002232	.979803E-03	.775374E+00	.206834E+03	.133213E-02	.917959E+00	.115559E+03	.103533E+01	.452926E-03
25	.002781	.143298E-02	.873360E+00	.140432E+03	.184994E-02	.963927E+00	.568690E+02	.102174E+01	.559300E-03
28	.003417	.200969E-02	.939941E+00	.783757E+02	.247105E-02	.987716E+00	.220538E+02	.101144E+01	.681008E-03
31	.004152	.271670E-02	.978358E+00	.329411E+02	.320172E-02	.997116E+00	.607167E+01	.100488E+01	.820737E-03
34	.005004	.355810E-02	.994827E+00	.929042E+01	.405216E-02	.999633E+00	.980860E+00	.100157E+01	.981715E-03
37	.005990	.454153E-02	.999231E+00	.150556E+01	.503782E-02	.999994E+00	.500944E-01	.100034E+01	.116767E-02
40	.007131	.568239E-02	.999952E+00	.113795E+00	.617900E-02	.100000E+01	-.463503E-02	.100004E+01	.138279E-02
43	.008452	.700241E-02	.999999E+00	.303503E-02	.750004E-02	.100000E+01	-.556650E-03	.100000E+01	.163178E-02
46	.009981	.853269E-02	.100000E+01	.188539E-04	.902932E-02	.100000E+01	-.131307E-04	.100000E+01	.192001E-02

49 .011752	.103030E-01	.100000E+01	.951090E-08	.107996E-01	.100000E+01	-.441094E-07	.100000E+01	.225368E-02
52 .013801	.123524E-01	.100000E+01	.241472E-08	.128490E-01	.100000E+01	-.398301E-08	.100000E+01	.263994E-02
52 .013801	.123524E-01	.100000E+01	.241472E-08	.128490E-01	.100000E+01	-.398301E-08	.100000E+01	.263994E-02

0 BOUNDARY-LAYER PARAMETERS

0 DELSTX =	.311793E-03	DELSTZ =	.218189E-03	THETAX =	.114497E-03	THETAZ =	.814573E-04
CFX =	.470472E-02	CFZ =	.675562E-02	HX =	.272315E+01	HZ =	.267857E+01

0 FLOW PARAMETERS

0 UE =	.592724E+03	WE =	.734372E+03	PE =	.710778E+03	TE =	.574457E+03
0 RHOE =	.721041E-03	MUE =	.404297E-06	BLP =	-.227836E+03	SQUIG =	-.321511E+00
0 TW =	.638460E+03	RHOW =	.648758E-03	VW =	-.753323E+00	CW =	.973628E+00

NZ= 6 NP= 52 DESTZ= .2181892663336E-03 RDSTZ= .2857648047160E+03

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.89185	-.55734	0.	.40465	-.98567E-01	1.1114	-.22310E-03	-.10796
2	.59999E-01	.52527E-01	.85908	-.54607	.24106E-01	.39888	-.96185E-01	1.1112	-.61028E-02	-.97996E-01
3	.12298	.10555	.82504	-.53496	.49035E-01	.39288	-.94441E-01	1.1106	-.11967E-01	-.88236E-01
4	.18906	.15890	.79006	-.52394	.74790E-01	.38667	-.93459E-01	1.1097	-.17480E-01	-.78632E-01
5	.25837	.21240	.75413	-.51272	.10137	.38020	-.93106E-01	1.1083	-.22604E-01	-.69209E-01
6	.33103	.26585	.71730	-.50102	.12875	.37343	-.93250E-01	1.1064	-.27299E-01	-.60005E-01
7	.40720	.31902	.67961	-.48858	.15692	.36631	-.93762E-01	1.1042	-.31528E-01	-.51070E-01
8	.48699	.37170	.64116	-.47518	.18585	.35880	-.94536E-01	1.1015	-.35260E-01	-.42459E-01
9	.57055	.42361	.60206	-.46064	.21550	.35086	-.95493E-01	1.0984	-.38464E-01	-.34235E-01
10	.65803	.47452	.56246	-.44482	.24583	.34246	-.96590E-01	1.0949	-.41119E-01	-.26462E-01
11	.74957	.52414	.52253	-.42767	.27677	.33356	-.97822E-01	1.0910	-.43209E-01	-.19200E-01
12	.84533	.57222	.48246	-.40915	.30827	.32412	-.99217E-01	1.0868	-.44727E-01	-.12504E-01
13	.94548	.61848	.44248	-.38928	.34023	.31411	-.10083	1.0823	-.45574E-01	-.64170E-02
14	1.0502	.66268	.40283	-.36814	.37256	.30345	-.10273	1.0775	-.46061E-01	-.97181E-03
15	1.1596	.70456	.36376	-.34580	.40516	.29209	-.10496	1.0724	-.45906E-01	.38134E-02
16	1.2740	.74389	.32556	-.32239	.43787	.27994	-.10754	1.0672	-.45234E-01	.79331E-02
17	1.3934	.78049	.28849	-.29806	.47055	.26692	-.11044	1.0618	-.44080E-01	.11393E-01
18	1.5183	.81418	.25285	-.27296	.50301	.25294	-.11352	1.0564	-.42482E-01	.14210E-01
19	1.6487	.84483	.21893	-.24732	.53502	.23794	-.11657	1.0510	-.40486E-01	.16407E-01
20	1.7849	.87235	.18701	-.22137	.56635	.22187	-.11928	1.0456	-.38141E-01	.18011E-01
21	1.9272	.89672	.15736	-.19544	.59672	.20476	-.12124	1.0404	-.35504E-01	.19055E-01
22	2.0758	.91796	.13020	-.16986	.62582	.18668	-.12201	1.0353	-.32633E-01	.19571E-01
23	2.2312	.93614	.10574	-.14504	.65335	.16779	-.12114	1.0305	-.29590E-01	.19596E-01
24	2.3936	.95140	.84108E-01	-.12140	.67900	.14835	-.11825	1.0260	-.26443E-01	.19170E-01
25	2.5634	.96393	.65368E-01	-.99358E-01	.70248	.12871	-.11310	1.0217	-.23259E-01	.18338E-01
26	2.7409	.97397	.49505E-01	-.79298E-01	.72356	.10930	-.10562	1.0179	-.20107E-01	.17154E-01
27	2.9267	.98180	.36424E-01	-.61527E-01	.74204	.90570E-01	-.95968E-01	1.0145	-.17058E-01	.15678E-01
28	3.1212	.98772	.25945E-01	-.46256E-01	.75784	.73018E-01	-.84557E-01	1.0114	-.14173E-01	.13986E-01

29	3.3248	.99204	.17818E-01	-.33572E-01	.77095	.57081E-01	-.71990E-01	1.0088	-.11512E-01	.12159E-01
30	3.5381	.99508	.11741E-01	-.23414E-01	.78149	.43112E-01	-.59004E-01	1.0067	-.91187E-02	.10280E-01
31	3.7616	.99712	.73798E-02	-.15609E-01	.78965	.31335E-01	-.46376E-01	1.0049	-.70270E-02	.84361E-02
32	3.9959	.99842	.43928E-02	-.98868E-02	.79572	.21824E-01	-.34807E-01	1.0035	-.52534E-02	.67025E-02
33	4.2416	.99920	.24528E-02	-.59034E-02	.80003	.14497E-01	-.24833E-01	1.0024	-.37983E-02	.51415E-02
34	4.4994	.99963	.12676E-02	-.32923E-02	.80294	.91367E-02	-.16755E-01	1.0016	-.26464E-02	.37961E-02
35	4.7698	.99986	.59350E-03	-.16928E-02	.80490	.54333E-02	-.10631E-01	1.0010	-.17696E-02	.26876E-02
36	5.0537	.99996	.24275E-03	-.77864E-03	.80591	.30297E-02	-.63046E-02	1.0006	-.11305E-02	.18156E-02
37	5.3516	.99999	.74348E-04	-.35175E-03	.80654	.15735E-02	-.34704E-02	1.0003	-.68654E-03	.11645E-02
38	5.6644	1.0000	.99041E-05	-.60322E-04	.80686	.75550E-03	-.17598E-02	1.0002	-.39407E-03	.70566E-03
39	5.9928	1.0000	0.	0.	.80701	.33269E-03	-.81533E-03	1.0001	-.21232E-03	.40133E-03
40	6.3376	1.0000	0.	0.	.80708	.13319E-03	-.34200E-03	1.0000	-.10652E-03	.21239E-03
41	6.6995	1.0000	0.	0.	.80710	.48010E-04	-.12861E-03	1.0000	-.49327E-04	.10362E-03
42	7.0796	1.0000	0.	0.	.80711	.15418E-04	-.42889E-04	1.0000	-.20871E-04	.46115E-04
43	7.4787	1.0000	0.	0.	.80712	.43589E-05	-.12532E-04	1.0000	-.79775E-05	.18500E-04
44	7.8979	1.0000	0.	0.	.80712	.10700E-05	-.31649E-05	1.0000	-.27165E-05	.65998E-05
45	8.3378	1.0000	0.	0.	.80712	.22429E-06	-.67945E-06	1.0000	-.81320E-06	.20607E-05
46	8.7997	1.0000	0.	0.	.80712	.39286E-07	-.12143E-06	1.0000	-.20958E-06	.55247E-06
47	9.2848	1.0000	0.	0.	.80712	.55798E-08	-.17543E-07	1.0000	-.45463E-07	.12416E-06
48	9.7942	1.0000	0.	0.	.80712	.61350E-09	-.19578E-08	1.0000	-.81285E-08	.22437E-07
49	10.329	1.0000	0.	0.	.80712	.48398E-10	-.15541E-09	1.0000	-.10903E-08	.38632E-08
50	10.891	1.0000	0.	0.	.80712	.28428E-11	-.68040E-11	1.0000	-.58253E-15	.18641E-13
51	11.480	1.0000	0.	0.	.80712	.12372E-11	.13607E-11	1.0000	-.50321E-15	.16103E-13
52	12.099	1.0000	0.	0.	.80712	.82920E-12	-.26787E-11	1.0000	0.	0.

0NZ = 7 X/C = .869990E-02

0 IT	VWALL	DFLVW	TWALL	DELTW
1	.481373E+03	-.352948E+02	.856400E+03	-.939048E+02
2	.446078E+03	-.157906E+01	.762495E+03	-.269512E+01
3	.444499E+03	.118221E+00	.759800E+03	.290730E+00
4	.444617E+03	.439855E-02	.760091E+03	.950528E-02
5	.444622E+03	-.154367E-03	.760100E+03	-.302418E-03
6	.444622E+03	-.359340E-05	.760100E+03	-.460874E-05

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.444622E+03	0.	0.	.760100E+03	.113430E+01	0.
4	.000197	.850001E-05	.857277E-01	.425663E+03	.142160E-04	.142025E+00	.682064E+03	.113251E+01	.429428E-04
7	.000425	.389299E-04	.180377E+00	.404331E+03	.635586E-04	.287749E+00	.596525E+03	.112683E+01	.924903E-04
10	.000689	.100348E-03	.283857E+00	.379434E+03	.159181E-03	.432953E+00	.504464E+03	.111698E+01	.149451E-03
13	.000995	.204345E-03	.395223E+00	.348836E+03	.313454E-03	.572106E+00	.407650E+03	.110311E+01	.214690E-03
16	.001349	.365197E-03	.511946E+00	.310494E+03	.539178E-03	.698624E+00	.309826E+03	.108599E+01	.289149E-03
19	.001758	.599570E-03	.629569E+00	.263579E+03	.848459E-03	.805862E+00	.217072E+03	.105701E+01	.373913E-03
22	.002232	.925559E-03	.741554E+00	.208942E+03	.125157E-02	.888739E+00	.136559E+03	.104802E+01	.470292E-03
25	.002781	.136088E-02	.839699E+00	.149605E+03	.175636E-02	.945422E+00	.743492E+02	.103098E+01	.579951E-03
28	.003417	.192035E-02	.915752E+00	.919029E+02	.236881E-02	.978324E+00	.332114E+02	.101747E+01	.705021E-03
31	.004152	.261394E-02	.964901E+00	.450263E+02	.309496E-02	.993590E+00	.112489E+02	.100825E+01	.848203E-03
34	.005004	.344759E-02	.989403E+00	.159658E+02	.394373E-02	.998775E+00	.254787E+01	.100309E+01	.101279E-02
37	.005990	.442902E-02	.997940E+00	.361226E+01	.492901E-02	.999893E+00	.298962E+00	.100084E+01	.120265E-02
40	.007131	.556818E-02	.999778E+00	.443859E+00	.607015E-02	.100000E+01	.512986E-02	.100015E+01	.142213E-02
43	.008452	.688913E-02	.999939E+00	.242865E-01	.739120E-02	.100000E+01	-.169574E-02	.100001E+01	.167612E-02

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46	.009981	.841840E-02	.100000E+01	.465097E-03	.892047E-02	.100000E+01	-.114798E-03	.100000E+01	.197013E-02
49	.011752	.101887E-01	.100000E+01	.218131E-05	.106908E-01	.100000E+01	-.181342E-05	.100000E+01	.231048E-02
52	.013801	.122381E-01	.100000E+01	.414721E-09	.127402E-01	.100000E+01	-.263959E-08	.100000E+01	.270448E-02
52	.013801	.122381E-01	.100000E+01	.414721E-09	.127402E-01	.100000E+01	-.263959E-08	.100000E+01	.270448E-02

0 BOUNDARY-LAYER PARAMETERS

0	DELSTX =	.351673E-03	DELSTZ =	.255147E-03	THETAX =	.126279E-03	THETAZ =	.920592E-04
	CFX =	.441109E-02	CFZ =	.536248E-02	HX =	.278489E+01	HZ =	.277158E+01

0 FLOW PARAMETERS

0	UE =	.592723E+03	WE =	.833513E+03	PE =	.656299E+03	TE =	.561516E+03
0	RHOE =	.681118E-03	MUE =	.397365E-06	BLP =	-.212809E+03	SQUIG =	-.319765E+00
0	TW =	.636928E+03	RHOW =	.600474E-03	VW =	-.732509E+00	CW =	.968909E+00

NZ= 7 NP= 52 DESTZ= .2551469285881E-03 RDSTZ= .3645321302661E+03

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.88916	-.55347	0.	.36989	-.95160E-01	1.1343	-.22909E-03	-.13760
2	.53414E-01	.46721E-01	.86025	-.54132	.19626E-01	.36498	-.91954E-01	1.1341	-.69640E-02	-.12609
3	.10948	.94100E-01	.83024	-.52912	.39944E-01	.35991	-.88936E-01	1.1335	-.13717E-01	-.11483
4	.16831	.14203	.79948	-.51673	.60962E-01	.35476	-.86118E-01	1.1325	-.20147E-01	-.10377
5	.23001	.19037	.76798	-.50433	.82687E-01	.34952	-.83692E-01	1.1311	-.26216E-01	-.92935E-01
6	.29470	.23900	.73575	-.49208	.10512	.34416	-.81840E-01	1.1292	-.31885E-01	-.82351E-01
7	.36250	.28775	.70279	-.48005	.12827	.33865	-.80716E-01	1.1268	-.37119E-01	-.72028E-01
8	.43352	.33645	.66912	-.46822	.15212	.33293	-.80434E-01	1.1240	-.41878E-01	-.61977E-01
9	.50790	.38492	.63473	-.45651	.17666	.32692	-.81053E-01	1.1207	-.46124E-01	-.52212E-01
10	.58575	.43295	.59965	-.44473	.20186	.32056	-.82575E-01	1.1170	-.49820E-01	-.42752E-01
11	.66720	.48032	.56392	-.43266	.22770	.31373	-.84942E-01	1.1128	-.52931E-01	-.33631E-01
12	.75238	.52679	.52760	-.41999	.25411	.30637	-.88043E-01	1.1081	-.55424E-01	-.24893E-01
13	.84144	.57211	.49080	-.40641	.28105	.29836	-.91724E-01	1.1031	-.57271E-01	-.16600E-01
14	.93450	.61602	.45367	-.39164	.30842	.28964	-.95804E-01	1.0977	-.58454E-01	-.86226E-02
15	1.0317	.65828	.41638	-.37543	.33613	.28011	-.10009	1.0920	-.58963E-01	-.16416E-02
16	1.1333	.69862	.37916	-.35761	.36405	.26973	-.10439	1.0860	-.58799E-01	.48633E-02
17	1.2393	.73681	.34228	-.33810	.39206	.25845	-.10851	1.0798	-.57979E-01	.10618E-01
18	1.3500	.77262	.30603	-.31691	.42000	.24623	-.11230	1.0734	-.56530E-01	.15563E-01
19	1.4655	.80586	.27074	-.29417	.44770	.23306	-.11559	1.0670	-.54496E-01	.19655E-01
20	1.5860	.83637	.23672	-.27008	.47496	.21897	-.11821	1.0606	-.51932E-01	.22875E-01
21	1.7119	.86402	.20432	-.24494	.50157	.20398	-.12000	1.0542	-.48905E-01	.25227E-01
22	1.8432	.88874	.17385	-.21912	.52733	.18817	-.12076	1.0480	-.45493E-01	.26735E-01
23	1.9803	.91052	.14559	-.19306	.55199	.17165	-.12028	1.0420	-.41779E-01	.27444E-01
24	2.1235	.92938	.11980	-.16722	.57533	.15457	-.11835	1.0363	-.37852E-01	.27416E-01
25	2.2730	.94542	.96675E-01	-.14211	.59712	.13714	-.11476	1.0310	-.33804E-01	.26724E-01
26	2.4292	.95879	.76340E-01	-.11824	.61714	.11963	-.10938	1.0260	-.29729E-01	.25457E-01
27	2.5925	.96968	.58846E-01	-.96065E-01	.63522	.10236	-.10217	1.0215	-.25715E-01	.23711E-01

28	2.7632	.97832	.44158E-01	-.76009E-01	.65120	.85685E-01	-.93226E-01	1.0175	-.21848E-01	.21591E-01
29	2.9418	.98500	.32158E-01	-.58383E-01	.66502	.69966E-01	-.82820E-01	1.0139	-.18205E-01	.19207E-01
30	3.1287	.98999	.22648E-01	-.43389E-01	.67665	.55556E-01	-.71379E-01	1.0108	-.14852E-01	.16677E-01
31	3.3244	.99359	.15361E-01	-.31081E-01	.68615	.42753E-01	-.59462E-01	1.0083	-.11839E-01	.14113E-01
32	3.5294	.99609	.99855E-02	-.21363E-01	.69367	.31770E-01	-.47692E-01	1.0061	-.92018E-02	.11619E-01
33	3.7442	.99774	.61850E-02	-.14017E-01	.69939	.22707E-01	-.36679E-01	1.0044	-.69560E-02	.92880E-02
34	3.9695	.99878	.36241E-02	-.87229E-02	.70358	.15543E-01	-.26931E-01	1.0031	-.51001E-02	.71909E-02
35	4.2057	.99939	.19905E-02	-.51076E-02	.70650	.10143E-01	-.18790E-01	1.0021	-.36157E-02	.53769E-02
36	4.4535	.99972	.10113E-02	-.27950E-02	.70944	.62788E-02	-.12395E-01	1.0014	-.24697E-02	.38719E-02
37	4.7136	.99989	.46472E-03	-.14083E-02	.70965	.36672E-02	-.76891E-02	1.0008	-.16185E-02	.26740E-02
38	4.9865	.99997	.18651E-03	-.63035E-03	.71036	.20094E-02	-.44588E-02	1.0005	-.10132E-02	.17614E-02
39	5.2730	.99999	.57466E-04	-.27046E-03	.71076	.10266E-02	-.24019E-02	1.0003	-.60305E-03	.11020E-02
40	5.5738	1.0000	.86001E-05	-.54468E-04	.71096	.48585E-03	-.11938E-02	1.0001	-.33931E-03	.65176E-03
41	5.8896	1.0000	0.	0.	.71105	.21153E-03	-.54356E-03	1.0001	-.17926E-03	.36191E-03
42	6.2211	1.0000	0.	0.	.71109	.84113E-04	-.22504E-03	1.0000	-.88243E-04	.18711E-03
43	6.5692	1.0000	0.	0.	.71111	.30314E-04	-.84047E-04	1.0000	-.40137E-04	.89264E-04
44	6.9348	1.0000	0.	0.	.71111	.99204E-05	-.29084E-04	1.0000	-.16712E-04	.36908E-04
45	7.3196	1.0000	0.	0.	.71111	.28344E-05	-.83212E-05	1.0000	-.63043E-05	.15327E-04
46	7.7216	1.0000	0.	0.	.71111	.72153E-06	-.21649E-05	1.0000	-.21296E-05	.53913E-05
47	8.1447	1.0000	0.	0.	.71111	.16008E-06	-.48887E-06	1.0000	-.63566E-06	.16701E-05
48	8.5890	1.0000	0.	0.	.71111	.30500E-07	-.94456E-07	1.0000	-.16506E-06	.44836E-06
49	9.0555	1.0000	0.	0.	.71111	.48942E-08	-.15321E-07	1.0000	-.36612E-07	.10231E-06
50	9.5453	1.0000	0.	0.	.71111	.64440E-09	-.20311E-08	1.0000	-.68207E-08	.19328E-07
51	10.060	1.0000	0.	0.	.71111	.67297E-10	-.21306E-09	1.0000	-.10469E-08	.31239E-08
52	10.600	1.0000	0.	0.	.71111	.48813E-11	-.18079E-10	1.0000	-.10169E-09	.37658E-09

ONZ = 8 Y/C = .122222E-01

0 IT	VWALL	DELVW	TWALL	DELTW
1	.444622E+03	-.331241E+02	.760100E+03	-.823697E+02
2	.411497E+03	-.158802E+01	.677730E+03	-.256980E+01
3	.409909E+03	.124410E+00	.675160E+03	.299253E+00
4	.410034E+03	.510266E-02	.675460E+03	.107361E-01
5	.410039E+03	-.199690E-03	.675470E+03	-.387180E-03
6	.410039E+03	-.573049E-05	.675470E+03	-.822401E-05

0 IT	VWALL	DELVW	TWALL	DELTW
1	.410039E+03	.153005E-06	.675470E+03	.243113E-06

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.410039E+03	0.	0.	.675470E+03	.115612E+01	0.
4	.000197	.785294E-05	.792578E-01	.394443E+03	.126973E-04	.127128E+00	.615191E+03	.115439E+01	.445887E-04
7	.000425	.360218E-04	.167113E+00	.375809E+03	.570715E-04	.259681E+00	.547478E+03	.114880E+01	.960422E-04
10	.000689	.929747E-04	.263410E+00	.353520E+03	.143796E-03	.394306E+00	.472967E+03	.113891E+01	.155204E-03
13	.000995	.189571E-03	.367448E+00	.327135E+03	.285080E-03	.526550E+00	.393500E+03	.112468E+01	.222967E-03
16	.001349	.339379E-03	.477657E+00	.295594E+03	.494173E-03	.651015E+00	.311658E+03	.110660E+01	.300283E-03
19	.001758	.558712E-03	.590936E+00	.257209E+03	.784506E-03	.761681E+00	.230920E+03	.108578E+01	.388215E-03
22	.002232	.866019E-03	.701991E+00	.211093E+03	.116852E-02	.852770E+00	.156223E+03	.106402E+01	.488015E-03
25	.002781	.128026E-02	.803398E+00	.158890E+03	.165656E-02	.920320E+00	.934435E+02	.104347E+01	.601256E-03
28	.003417	.181901E-02	.886926E+00	.105494E+03	.225659E-02	.963873E+00	.473111E+02	.102620E+01	.729981E-03
31	.004152	.249515E-02	.946262E+00	.583927E+02	.297530E-02	.987129E+00	.190605E+02	.101356E+01	.876839E-03
34	.005004	.331727E-02	.980396E+00	.248902E+02	.382071E-02	.996733E+00	.557490E+01	.100575E+01	.104515E-02

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37	.005990	.429220E-02	.995022E+00	.735149E+01	.480496E-02	.999505E+00	.101791E+01	.100187E+01	.123890E-02
40	.007131	.543065E-02	.999223E+00	.131578E+01	.594592E-02	.999973E+00	.803064E-01	.100043E+01	.146262E-02
43	.008452	.675129E-02	.999936E+00	.121392E+00	.726696E-02	.100000E+01	-.109356E-02	.100006E+01	.172140E-02
46	.009981	.828053E-02	.999998E+00	.479942E-02	.879623E-02	.100000E+01	-.491184E-03	.100000E+01	.202091E-02
49	.011752	.100509E-01	.100000E+01	.652271E-04	.105666E-01	.100000E+01	-.206851E-04	.100000E+01	.236762E-02
52	.013801	.121002E-01	.100000E+01	.214516E-06	.126159E-01	.100000E+01	-.202226E-06	.100000E+01	.276899E-02
55	.016173	.144726E-01	.100000E+01	-.175557E-09	.149883E-01	.100000E+01	.165380E-08	.100000E+01	.323362E-02
55	.016173	.144726E-01	.100000E+01	-.175557E-09	.149883E-01	.100000E+01	.165380E-08	.100000E+01	.323362E-02

0 BOUNDARY-LAYER PARAMETERS

0 DELSTX	=	.399183E-03	DELSTZ	=	.298184E-03	THETAX	=	.140249E-03	THETAZ	=	.104429E-03
CFX	=	.412566E-02	CFZ	=	.440280E-02	HX	=	.284625E+01	HZ	=	.285536E+01

0 FLOW PARAMETERS

0 UE	=	.592723E+03	WE	=	.914950E+03	PE	=	.609073E+03	TE	=	.549662E+03
0 RHOE	=	.645738E-03	MUE	=	.390945E-06	BLP	=	-.185372E+03	SQUIG	=	-.296968E+00
0 TW	=	.635476E+03	RHOW	=	.558538E-03	VW	=	-.662505E+00	CW	=	.964606E+00

NZ= 8 NP= 55 DESTZ= .2981837677805E-03 RDSTZ= .4506318673094E+03

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.88943	-.53709	0.	.34979	-.88429E-01	1.1561	-.21569E-03	-.16680
2	.47455E-01	.41614E-01	.86440	-.52739	.16502E-01	.34570	-.86358E-01	1.1559	-.75538E-02	-.15463
3	.97267E-01	.84017E-01	.83836	-.51825	.33615E-01	.34143	-.84793E-01	1.1554	-.14956E-01	-.14259
4	.14953	.12713	.81149	-.50973	.51345E-01	.33703	-.83829E-01	1.1544	-.22095E-01	-.13057
5	.20436	.17085	.78377	-.50147	.69696E-01	.33244	-.83300E-01	1.1530	-.28926E-01	-.11860
6	.26184	.21508	.75519	-.49314	.88669E-01	.32766	-.83059E-01	1.1511	-.35401E-01	-.10669
7	.32209	.25968	.72574	-.48449	.10826	.32266	-.82998E-01	1.1488	-.41474E-01	-.94900E-01
8	.38521	.30452	.69544	-.47534	.12846	.31742	-.83058E-01	1.1460	-.47097E-01	-.83282E-01
9	.45131	.34945	.66435	-.46559	.14926	.31192	-.83236E-01	1.1427	-.52226E-01	-.71699E-01
10	.52050	.39431	.63249	-.45520	.17064	.30615	-.83585E-01	1.1389	-.56517E-01	-.60813E-01
11	.59289	.43890	.59994	-.44420	.19259	.30008	-.84202E-01	1.1346	-.60831E-01	-.50078E-01
12	.66860	.48305	.56675	-.43260	.21506	.29367	-.85206E-01	1.1299	-.64231E-01	-.39745E-01
13	.74775	.52655	.53299	-.42044	.23804	.28686	-.86719E-01	1.1247	-.65985E-01	-.29855E-01
14	.83045	.56919	.49874	-.40768	.26147	.27960	-.88835E-01	1.1190	-.69065E-01	-.20447E-01
15	.91684	.61076	.46411	-.39424	.28529	.27181	-.91598E-01	1.1130	-.70448E-01	-.11561E-01
16	1.0070	.65102	.42919	-.37998	.30944	.26340	-.94982E-01	1.1066	-.71116E-01	-.32419E-02
17	1.1012	.68974	.39413	-.36469	.33381	.25427	-.98884E-01	1.0999	-.71059E-01	.44531E-02
18	1.1994	.72670	.35912	-.34817	.35832	.24435	-.10312	1.0929	-.70277E-01	.11456E-01
19	1.3019	.76168	.32435	-.33020	.38282	.23355	-.10746	1.0858	-.68783E-01	.17690E-01
20	1.4088	.79447	.29009	-.31066	.40717	.22184	-.11160	1.0785	-.66604E-01	.23076E-01
21	1.5203	.82488	.25654	-.28950	.43122	.20920	-.11524	1.0712	-.63782E-01	.27538E-01
22	1.6365	.85277	.22429	-.26678	.45476	.19563	-.11805	1.0640	-.60378E-01	.31019E-01
23	1.7579	.87801	.19340	-.24270	.47762	.18121	-.11975	1.0569	-.56466E-01	.33482E-01

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24	1.8844	.90053	.16428	-.21761	.49959	.16604	-.12006	1.0500	-.52140E-01	.34925E-01
25	2.0164	.92032	.13725	-.19195	.52046	.15028	-.11877	1.0435	-.47500E-01	.35376E-01
26	2.1541	.93740	.11259	-.16624	.54003	.13414	-.11572	1.0373	-.42661E-01	.34900E-01
27	2.2979	.95187	.90491E-01	-.14107	.55812	.11785	-.11084	1.0315	-.37736E-01	.33593E-01
28	2.4481	.96387	.71111E-01	-.11703	.57457	.10170	-.10414	1.0262	-.32843E-01	.31577E-01
29	2.6050	.97359	.54500E-01	-.94689E-01	.58924	.86024E-01	-.95732E-01	1.0214	-.28091E-01	.28996E-01
30	2.7690	.98126	.40624E-01	-.74499E-01	.60207	.71129E-01	-.85878E-01	1.0172	-.23580E-01	.26004E-01
31	2.9406	.98713	.29358E-01	-.56823E-01	.61301	.57333E-01	-.74947E-01	1.0136	-.19397E-01	.22761E-01
32	3.1201	.99148	.20498E-01	-.41877E-01	.62209	.44911E-01	-.63423E-01	1.0104	-.15609E-01	.19426E-01
33	3.3081	.99460	.13770E-01	-.29702E-01	.62942	.34075E-01	-.51857E-01	1.0079	-.12266E-01	.16145E-01
34	3.5051	.99673	.88572E-02	-.20188E-01	.63512	.24950E-01	-.40810E-01	1.0057	-.93913E-02	.13049E-01
35	3.7115	.99813	.54235E-02	-.13085E-01	.63940	.17562E-01	-.30786E-01	1.0041	-.69390E-02	.10232E-01
36	3.9279	.99900	.31391E-02	-.80280E-02	.64248	.11833E-01	-.22164E-01	1.0028	-.50417E-02	.77657E-02
37	4.1548	.99950	.17027E-02	-.46299E-02	.64459	.75976E-02	-.15158E-01	1.0019	-.35147E-02	.56901E-02
38	4.3929	.99978	.85424E-03	-.24963E-02	.64597	.46262E-02	-.97990E-02	1.0012	-.23593E-02	.40142E-02
39	4.6428	.99991	.38779E-03	-.12371E-02	.64682	.26577E-02	-.59559E-02	1.0007	-.15186E-02	.27142E-02
40	4.9051	.99997	.15417E-03	-.54444E-03	.64732	.14329E-02	-.33846E-02	1.0004	-.93329E-03	.17495E-02
41	5.1804	1.0000	.49704E-04	-.22166E-03	.64758	.72084E-03	-.17877E-02	1.0002	-.54507E-03	.10705E-02
42	5.4695	1.0000	.85377E-05	-.56268E-04	.64772	.33640E-03	-.87234E-03	1.0001	-.30089E-03	.61911E-03
43	5.7729	1.0000	0.	0.	.64778	.14474E-03	-.39075E-03	1.0001	-.15594E-03	.33615E-03
44	6.0916	1.0000	0.	0.	.64780	.57059E-04	-.15963E-03	1.0000	-.75310E-04	.16994E-03
45	6.4261	1.0000	0.	0.	.64781	.20473E-04	-.59084E-04	1.0000	-.33618E-04	.79297E-04
46	6.7774	1.0000	0.	0.	.64782	.66398E-05	-.19676E-04	1.0000	-.13749E-04	.33830E-04
47	7.1462	1.0000	0.	0.	.64782	.19319E-05	-.58523E-05	1.0000	-.51016E-05	.13061E-04
48	7.5335	1.0000	0.	0.	.64782	.50007E-06	-.15421E-05	1.0000	-.16988E-05	.45119E-05
49	7.9401	1.0000	0.	0.	.64782	.11404E-06	-.35658E-06	1.0000	-.50152E-06	.13769E-05
50	8.3671	1.0000	0.	0.	.64782	.22640E-07	-.71532E-07	1.0000	-.12954E-06	.36550E-06
51	8.8154	1.0000	0.	0.	.64782	.38548E-08	-.12269E-07	1.0000	-.29325E-07	.81568E-07
52	9.2862	1.0000	0.	0.	.64782	.55193E-09	-.17643E-08	1.0000	-.51367E-08	.20967E-07
53	9.7805	1.0000	0.	0.	.64782	.64607E-10	-.20748E-09	1.0000	-.42713E-15	.27336E-13
54	10.299	1.0000	0.	0.	.64782	.58076E-11	-.19104E-10	1.0000	-.36897E-15	.23614E-13
55	10.844	1.0000	0.	0.	.64782	.29990E-12	-.11007E-11	1.0000	0.	0.

ONZ = 9 Y/C = .163775E-01

0 IT	VWALL	DELVW	TWALL	DELTW
1	.410039E+03	-.402938E+02	.675470E+03	-.781550E+02
2	.369745E+03	-.177561E+01	.597315E+03	-.263675E+01
3	.367969E+03	.124818E+00	.594678E+03	.296790E+00
4	.368094E+03	.576718E-02	.594975E+03	.120395E-01
5	.368100E+03	-.218263E-03	.594987E+03	-.431366E-03
6	.368100E+03	-.792183E-05	.594987E+03	-.121294E-04

0 IT	VWALL	DELVW	TWALL	DELTW
1	.368100E+03	.220624E-06	.594987E+03	.379276E-06

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.368100E+03	0.	0.	.594987E+03	.117648E+01	0.
4	.000197	.706538E-05	.713796E-01	.356490E+03	.112323E-04	.112671E+00	.548913E+03	.117491E+01	.461544E-04
7	.000425	.324981E-04	.151180E+00	.343238E+03	.507349E-04	.231973E+00	.497498E+03	.116973E+01	.994312E-04
10	.000689	.841880E-04	.239727E+00	.327297E+03	.128620E-03	.355742E+00	.440355E+03	.116036E+01	.160723E-03
13	.000995	.172427E-03	.336726E+00	.307080E+03	.256879E-03	.480627E+00	.377331E+03	.114647E+01	.230965E-03

16	.001349	.310241E-03	.440887E+00	.281349E+03	.449044E-03	.601995E+00	.309619E+03	.112821E+01	.311140E-03
19	.001758	.513506E-03	.549552E+00	.249463E+03	.719487E-03	.714262E+00	.240045E+03	.110643E+01	.402309E-03
22	.002232	.800674E-03	.658866E+00	.211028E+03	.108237E-02	.811594E+00	.172595E+03	.108265E+01	.505681E-03
25	.002781	.119175E-02	.762411E+00	.166402E+03	.155046E-02	.888968E+00	.112025E+03	.105904E+01	.622737E-03
28	.003417	.170631E-02	.852577E+00	.118259E+03	.213419E-02	.943656E+00	.632197E+02	.103794E+01	.755396E-03
31	.004152	.236085E-02	.921991E+00	.723241E+02	.284182E-02	.976622E+00	.294669E+02	.102132E+01	.906192E-03
34	.005004	.316705E-02	.966861E+00	.357060E+02	.368130E-02	.992639E+00	.105519E+02	.101007E+01	.107840E-02
37	.005990	.412299E-02	.989583E+00	.130388E+02	.466325E-02	.998434E+00	.260569E+01	.100380E+01	.127606E-02
40	.007131	.526791E-02	.997820E+00	.314201E+01	.580363E-02	.999821E+00	.368416E+00	.100106E+01	.150389E-02
43	.008452	.658768E-02	.999733E+00	.434385E+00	.712460E-02	.999996E+00	.169096E-01	.100020E+01	.176719E-02
46	.009981	.811681E-02	.999984E+00	.293667E-01	.865388E-02	.100000E+01	-.965501E-03	.100002E+01	.207185E-02
49	.011752	.988713E-02	.100000E+01	.813547E-03	.104242E-01	.100000E+01	-.118036E-03	.100000E+01	.242452E-02
52	.013801	.119365E-01	.100000E+01	.735507E-05	.124736E-01	.100000E+01	-.301983E-05	.100000E+01	.283276E-02
55	.016173	.143089E-01	.100000E+01	.148434E-07	.148460E-01	.100000E+01	-.160732E-07	.100000E+01	.330536E-02
58	.018920	.170553E-01	.100000E+01	.852072E-10	.175923E-01	.100000E+01	-.833495E-09	.100000E+01	.385245E-02
58	.018920	.170553E-01	.100000E+01	.852072E-10	.175923E-01	.100000E+01	-.833495E-09	.100000E+01	.385245E-02

0 BOUNDARY-LAYER PARAMETERS

0 DELSTX	=	.454945E-03	DELSTZ	=	.347956E-03	THETAX	=	.155801E-03	THETAZ	=	.118284E-03
CFX	=	.375215E-02	CFZ	=	.365860E-02	HX	=	.292003E+01	HZ	=	.294171E+01

0 FLOW PARAMETERS

0 UE	=	.592722E+03	WE	=	.982559E+03	PE	=	.568649E+03	TE	=	.538982E+03
0 RHOE	=	.614827E-03	MUE	=	.385103E-06	BLP	=	-.155296E+03	SQUIG	=	-.265161E+00
0 TW	=	.634101E+03	RHOW	=	.522600E-03	VW	=	-.574467E+00	CW	=	.960757E+00

NZ= 9 NP= 58 DESTZ= .3479557132083E-03 RDSTZ= .5458311517673E+03

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.88327	-.52308	0.	.32965	-.79248E-01	1.1765	-.19201E-03	-.19091
2	.42093E-01	.36725E-01	.86168	-.51277	.13808E-01	.32643	-.76508E-01	1.1763	-.77127E-02	-.17867
3	.86278E-01	.74298E-01	.83925	-.50256	.28157E-01	.32311	-.73915E-01	1.1758	-.15340E-01	-.16658
4	.13264	.11267	.81619	-.49234	.43059E-01	.31974	-.71473E-01	1.1749	-.22785E-01	-.15457
5	.18128	.15179	.79248	-.48251	.58527E-01	.31631	-.69422E-01	1.1736	-.30013E-01	-.14263
6	.23229	.19158	.76810	-.47336	.74570E-01	.31261	-.67972E-01	1.1719	-.36986E-01	-.13078
7	.28576	.23197	.74301	-.46505	.91199E-01	.30919	-.67274E-01	1.1697	-.43663E-01	-.11898
8	.34178	.27287	.71717	-.45762	.10842	.30542	-.67414E-01	1.1671	-.50000E-01	-.10722
9	.40047	.31417	.69051	-.45096	.12622	.30144	-.68400E-01	1.1640	-.55947E-01	-.95477E-01
10	.46191	.35574	.66299	-.44485	.14461	.29718	-.70171E-01	1.1604	-.61453E-01	-.83749E-01
11	.52620	.39745	.63458	-.43895	.16358	.29259	-.72612E-01	1.1562	-.66462E-01	-.72057E-01
12	.59346	.43914	.60526	-.43292	.18309	.28761	-.75579E-01	1.1516	-.70917E-01	-.60446E-01
13	.66378	.48063	.57505	-.42638	.20313	.28217	-.78920E-01	1.1465	-.74765E-01	-.48986E-01
14	.73727	.52174	.54398	-.41901	.22365	.27624	-.82508E-01	1.1408	-.77953E-01	-.37766E-01
15	.81403	.56226	.51214	-.41057	.24461	.26976	-.86251E-01	1.1347	-.80434E-01	-.26888E-01

ORIGINAL PAGE IS
OF POOR QUALITY

16	.89419	.60200	.47962	-.40086	.26596	.26270	-.90099E-01	1.1282	-.82172E-01	-.16460E-01
17	.97786	.64072	.44654	-.38977	.28763	.25499	-.94035E-01	1.1213	-.83136E-01	-.65851E-02
18	1.0652	.67822	.41307	-.37720	.30953	.24661	-.98059E-01	1.1140	-.83308E-01	.26377E-02
19	1.1562	.71426	.37936	-.36310	.33157	.23749	-.10215	1.1064	-.82682E-01	.11119E-01
20	1.2511	.74864	.34564	-.34740	.35366	.22760	-.10627	1.0986	-.81263E-01	.18773E-01
21	1.3501	.78115	.31211	-.33005	.37567	.21688	-.11029	1.0907	-.79071E-01	.25522E-01
22	1.4533	.81159	.27904	-.31100	.39746	.20531	-.11402	1.0827	-.76140E-01	.31288E-01
23	1.5608	.83980	.24672	-.29024	.41887	.19288	-.11722	1.0746	-.72523E-01	.35999E-01
24	1.6729	.86563	.21545	-.26785	.43975	.17961	-.11958	1.0667	-.68287E-01	.39594E-01
25	1.7897	.88897	.18555	-.24400	.45992	.16557	-.12079	1.0590	-.63520E-01	.42030E-01
26	1.9115	.90976	.15736	-.21899	.47919	.15088	-.12054	1.0516	-.58324E-01	.43295E-01
27	2.0385	.92797	.13118	-.19325	.49738	.13569	-.11857	1.0446	-.52818E-01	.43413E-01
28	2.1710	.94366	.10730	-.16731	.51431	.12024	-.11473	1.0379	-.47131E-01	.42447E-01
29	2.3092	.95689	.85934E-01	-.14179	.52984	.10478	-.10896	1.0319	-.41397E-01	.40505E-01
30	2.4535	.96782	.67231E-01	-.11735	.54383	.89599E-01	-.10133	1.0263	-.35750E-01	.37739E-01
31	2.6043	.97662	.51252E-01	-.94593E-01	.55618	.75019E-01	-.92061E-01	1.0213	-.30317E-01	.34327E-01
32	2.7619	.98352	.37963E-01	-.74050E-01	.56686	.61342E-01	-.81491E-01	1.0170	-.25211E-01	.30469E-01
33	2.9268	.98878	.27235E-01	-.56124E-01	.57587	.48851E-01	-.70084E-01	1.0132	-.20526E-01	.26370E-01
34	3.0992	.99264	.18855E-01	-.41037E-01	.58325	.37772E-01	-.58375E-01	1.0101	-.16335E-01	.22230E-01
35	3.2798	.99537	.12546E-01	-.28831E-01	.58912	.28263E-01	-.46931E-01	1.0075	-.12682E-01	.18229E-01
36	3.4690	.99723	.79853E-02	-.19388E-01	.59363	.20392E-01	-.36282E-01	1.0054	-.95842E-02	.14519E-01
37	3.6673	.99843	.48325E-02	-.12413E-01	.59696	.14132E-01	-.26865E-01	1.0038	-.70333E-02	.11210E-01
38	3.8752	.99917	.27616E-02	-.75091E-02	.59932	.93671E-02	-.18970E-01	1.0026	-.49983E-02	.83672E-02
39	4.0933	.99959	.14777E-02	-.42662E-02	.60091	.59124E-02	-.12715E-01	1.0017	-.34292E-02	.60233E-02
40	4.3221	.99982	.73088E-03	-.22619E-02	.60193	.35370E-02	-.80501E-02	1.0011	-.22631E-02	.41700E-02
41	4.5622	.99993	.32715E-03	-.11010E-02	.60254	.19955E-02	-.47897E-02	1.0006	-.14307E-02	.27639E-02
42	4.8142	.99998	.12834E-03	-.47664E-03	.60290	.10563E-02	-.26636E-02	1.0004	-.86254E-03	.17446E-02
43	5.0788	1.0000	.40652E-04	-.18626E-03	.60308	.52161E-03	-.13769E-02	1.0002	-.49366E-03	.10440E-02
44	5.3565	1.0000	.75718E-05	-.51928E-04	.60317	.23924E-03	-.65776E-03	1.0001	-.26678E-03	.58969E-03
45	5.6482	1.0000	0.	0.	.60322	.10123E-03	-.28873E-03	1.0000	-.13523E-03	.31244E-03
46	5.9544	1.0000	0.	0.	.60323	.39300E-04	-.11577E-03	1.0000	-.63823E-04	.15399E-03
47	6.2759	1.0000	0.	0.	.60324	.13915E-04	-.42145E-04	1.0000	-.27818E-04	.69990E-04
48	6.6134	1.0000	0.	0.	.60324	.44652E-05	-.13843E-04	1.0000	-.11099E-04	.29061E-04
49	6.9679	1.0000	0.	0.	.60324	.12896E-05	-.40752E-05	1.0000	-.40152E-05	.10912E-04
50	7.3401	1.0000	0.	0.	.60324	.33265E-06	-.10672E-05	1.0000	-.13027E-05	.36643E-05
51	7.7308	1.0000	0.	0.	.60324	.75963E-07	-.24650E-06	1.0000	-.37438E-06	.10867E-05
52	8.1412	1.0000	0.	0.	.60324	.15196E-07	-.49702E-07	1.0000	-.93909E-07	.28040E-06
53	8.5720	1.0000	0.	0.	.60324	.26281E-08	-.86378E-08	1.0000	-.20219E-07	.61684E-07
54	9.0244	1.0000	0.	0.	.60324	.38642E-09	-.12729E-08	1.0000	-.37121E-08	.11294E-07
55	9.4994	1.0000	0.	0.	.60324	.47194E-10	-.15543E-09	1.0000	-.52749E-09	.21152E-08
56	9.9981	1.0000	0.	0.	.60324	.46358E-11	-.15220E-10	1.0000	.58204E-14	.53215E-13
57	10.522	1.0000	0.	0.	.60324	.37817E-12	-.10343E-11	1.0000	-.71827E-15	0.
58	11.072	1.0000	0.	0.	.60324	.48458E-13	-.17625E-12	1.0000	0.	0.

ONZ = 10 X/C = .211690E-01

0 IT	VWALL	DELVW	TWALL	DELTW
1	.369100E+03	-.390991E+02	.594987E+03	-.700781E+02
2	.329001E+03	-.175319E+01	.524908E+03	-.250986E+01
3	.327247E+03	.117534E+00	.522399E+03	.282576E+00

4	.327365E+03	.593689E-02	.522681E+03	.124932E-01
5	.327371E+03	-.228046E-03	.522694E+03	-.460517E-03
6	.327371E+03	-.974753E-05	.522693E+03	-.157444E-04

0 J	ETA	F	U	V	G	W	T	TEMP-R	Y-FT
1	0.000000	0.	0.	.327371E+03	0.	0.	.522693E+03	.119571E+01	0.
4	.000197	.630418E-05	.637741E-01	.319907E+03	.991567E-05	.996684E-01	.489017E+03	.119432E+01	.476628E-04
7	.000425	.290872E-04	.135690E+00	.310473E+03	.450126E-04	.206766E+00	.450105E+03	.118967E+01	.102700E-03
10	.000689	.755917E-04	.216108E+00	.298610E+03	.114751E-03	.319738E+00	.405793E+03	.118108E+01	.166059E-03
13	.000995	.155358E-03	.305154E+00	.283869E+03	.230618E-03	.436174E+00	.356422E+03	.116805E+01	.236735E-03
16	.001349	.280700E-03	.402331E+00	.265083E+03	.406060E-03	.552637E+00	.302371E+03	.115040E+01	.321764E-03
19	.001758	.467034E-03	.505988E+00	.240625E+03	.656053E-03	.664484E+00	.244565E+03	.112851E+01	.416233E-03
22	.002232	.732802E-03	.612782E+00	.209475E+03	.996216E-03	.766110E+00	.185421E+03	.110357E+01	.523331E-03
25	.002781	.109874E-02	.717454E+00	.171827E+03	.144154E-02	.851843E+00	.128903E+03	.107751E+01	.644457E-03
28	.003417	.158428E-02	.813017E+00	.129376E+03	.200512E-02	.917327E+00	.796983E+02	.105284E+01	.781390E-03
31	.004152	.221505E-02	.891798E+00	.860365E+02	.269751E-02	.961069E+00	.419814E+02	.103199E+01	.936500E-03
34	.005004	.300042E-02	.947935E+00	.478971E+02	.352759E-02	.985431E+00	.177479E+02	.101664E+01	.111294E-02
37	.005990	.395290E-02	.980541E+00	.207563E+02	.450510E-02	.996029E+00	.553256E+01	.100711E+01	.131472E-02
40	.007131	.508140E-02	.994837E+00	.635663E+01	.564403E-02	.999316E+00	.111759E+01	.100235E+01	.154670E-02
43	.008452	.639911E-02	.999131E+00	.121753E+01	.696472E-02	.999946E+00	.114259E+00	.100055E+01	.181442E-02
46	.009981	.792784E-02	.999919E+00	.126392E+00	.849397E-02	.100000E+01	.203288E-02	.100008E+01	.212402E-02
49	.011752	.969812E-02	.999996E+00	.608108E-02	.102643E-01	.100000E+01	-.375265E-03	.100001E+01	.246233E-02
52	.013801	.117475E-01	.100000E+01	.113820E-03	.123137E-01	.100000E+01	-.227062E-04	.100000E+01	.289712E-02
55	.016173	.141199E-01	.100000E+01	.653006E-06	.146861E-01	.100000E+01	-.335190E-06	.100000E+01	.337728E-02
58	.018920	.168663E-01	.100000E+01	.133885E-08	.174324E-01	.100000E+01	-.115792E-08	.100000E+01	.393313E-02
58	.018920	.168663E-01	.100000E+01	.133885E-08	.174324E-01	.100000E+01	-.115792E-08	.100000E+01	.393313E-02

```
0  BOUNDARY-LAYER PARAMETERS
0  DELSTX =   .519481E-03   DELSTZ =   .404889E-03   THETAX =   .173172E-03   THETAZ =   .133778E-03
   CFX    =   .337810E-02   CFZ    =   .307154E-02   HX     =   .299979E+01   HZ     =   .302657E+01

0  FLOW PARAMETERS
0  UE     =   .592721E+03   WE     =   .104081E+04   PE     =   .533231E+03   TE     =   .529169E+03
0  RHOE   =   .587223E-03   MUE    =   .379686E-06   BLP    =  -.107930E+03   SQUIG  =  -.196037E+00
0  TW     =   .622731E+03   RHOW   =   .491110E-03   VW     =  -.412273E+00   CW     =   .957265E+00


 NZ=   10   NP=   58   DESTZ=  .40488891249890E-03   RDSTZ=  .65176174832598E+03
```

J	Y	W	W1	W2	U	U1	U2	T	T1	T2
1	0.	0.	.87444	-.47901	0.	.31190	-.58696E-01	1.1957	-.15592E-03	-.21154
2	.37354E-01	.32334E-01	.85677	-.47305	.11611E-01	.30975	-.57634E-01	1.1956	-.76413E-02	-.20039
3	.76567E-01	.65566E-01	.83832	-.46793	.23712E-01	.30750	-.57056E-01	1.1951	-.15279E-01	-.18918
4	.11772	.99668E-01	.81915	-.46368	.36318E-01	.30515	-.57062E-01	1.1943	-.22830E-01	-.17779
5	.16089	.13460	.79922	-.45982	.49439E-01	.30268	-.57417E-01	1.1932	-.30256E-01	-.16622
6	.20617	.17032	.77848	-.45593	.63086E-01	.30007	-.57927E-01	1.1916	-.37517E-01	-.15448

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7	.25365	.20677	.75694	-.45173	.77267E-01	.29730	-.58468E-01	1.1897	-.44569E-01	-.14261
8	.30341	.24387	.73458	-.44708	.91988E-01	.29438	-.59000E-01	1.1873	-.51368E-01	-.13067
9	.35554	.28156	.71140	-.44200	.10725	.29129	-.59568E-01	1.1844	-.57968E-01	-.11869
10	.41013	.31974	.68742	-.43661	.12307	.28802	-.60291E-01	1.1811	-.64021E-01	-.10672
11	.46729	.35831	.66262	-.43110	.13943	.28454	-.61333E-01	1.1773	-.69780E-01	-.94795E-01
12	.52709	.39717	.63700	-.42565	.15634	.28083	-.62873E-01	1.1729	-.75093E-01	-.82914E-01
13	.58963	.43617	.61055	-.42036	.17378	.27683	-.65062E-01	1.1681	-.79909E-01	-.71082E-01
14	.65502	.47520	.58323	-.41524	.19174	.27248	-.68000E-01	1.1627	-.84172E-01	-.59303E-01
15	.72334	.51407	.55503	-.41016	.21020	.26771	-.71707E-01	1.1568	-.87323E-01	-.47590E-01
16	.79470	.55264	.52595	-.40487	.22912	.26243	-.76130E-01	1.1504	-.90305E-01	-.35981E-01
17	.86919	.59069	.49601	-.39903	.24846	.25657	-.81143E-01	1.1435	-.93059E-01	-.24545E-01
18	.94693	.62805	.46525	-.39226	.26816	.25006	-.86576E-01	1.1362	-.94534E-01	-.13384E-01
19	1.0290	.66448	.43377	-.38417	.28815	.24281	-.92237E-01	1.1285	-.95183E-01	-.26284E-02
20	1.1126	.69979	.40170	-.37444	.30835	.23477	-.97934E-01	1.1205	-.94974E-01	.75698E-02
21	1.2007	.73373	.36922	-.36279	.32866	.22589	-.10349	1.1121	-.93889E-01	.17051E-01
22	1.2925	.76611	.33653	-.34906	.34897	.21615	-.10873	1.1036	-.91928E-01	.25657E-01
23	1.3882	.79671	.30390	-.33314	.36915	.20552	-.11350	1.0949	-.89110E-01	.33241E-01
24	1.4879	.82534	.27160	-.31501	.38907	.19400	-.11760	1.0862	-.85477E-01	.39676E-01
25	1.5917	.85184	.23995	-.29474	.40857	.18162	-.12084	1.0775	-.81089E-01	.44857E-01
26	1.6998	.87607	.20928	-.27246	.42751	.16844	-.12296	1.0690	-.76030E-01	.48705E-01
27	1.8125	.89792	.17993	-.24843	.44570	.15454	-.12371	1.0607	-.70404E-01	.51173E-01
28	1.9299	.91733	.15226	-.22301	.46300	.14007	-.12284	1.0528	-.64333E-01	.52255E-01
29	2.0523	.93429	.12658	-.19670	.47922	.12521	-.12012	1.0454	-.57955E-01	.51988E-01
30	2.1799	.94884	.10318	-.17007	.49421	.11018	-.11542	1.0384	-.51419E-01	.50455E-01
31	2.3130	.96107	.82230E-01	-.14381	.50796	.95260E-01	-.10973	1.0320	-.44879E-01	.47794E-01
32	2.4519	.97112	.64056E-01	-.11863	.52005	.80745E-01	-.10018	1.0262	-.38488E-01	.44191E-01
33	2.5971	.97916	.48541E-01	-.95188E-01	.53071	.66941E-01	-.90043E-01	1.0211	-.32388E-01	.39868E-01
34	2.7487	.98543	.35703E-01	-.74085E-01	.53983	.54141E-01	-.78742E-01	1.0166	-.26705E-01	.35074E-01
35	2.9074	.99016	.25406E-01	-.55751E-01	.54742	.42598E-01	-.66805E-01	1.0128	-.21539E-01	.30062E-01
36	3.0733	.99361	.17426E-01	-.40408E-01	.55357	.32505E-01	-.54814E-01	1.0097	-.16964E-01	.25069E-01
37	3.2471	.99603	.11474E-01	-.28098E-01	.55840	.23976E-01	-.43350E-01	1.0071	-.13020E-01	.20314E-01
38	3.4292	.99765	.72165E-02	-.18673E-01	.56204	.17033E-01	-.32925E-01	1.0051	-.97175E-02	.15971E-01
39	3.6200	.99869	.43099E-02	-.11792E-01	.56469	.11609E-01	-.23920E-01	1.0035	-.70340E-02	.12155E-01
40	3.8201	.99932	.24274E-02	-.70257E-02	.56654	.75603E-02	-.16553E-01	1.0023	-.49245E-02	.89315E-02
41	4.0299	.99967	.12783E-02	-.39248E-02	.56776	.46836E-02	-.10861E-01	1.0015	-.33240E-02	.63205E-02
42	4.2502	.99986	.62144E-03	-.20406E-02	.56853	.27474E-02	-.67241E-02	1.0009	-.21552E-02	.42945E-02
43	4.4813	.99995	.27320E-03	-.97287E-03	.56898	.15187E-02	-.39088E-02	1.0006	-.13366E-02	.27894E-02
44	4.7239	.99998	.10516E-03	-.41256E-03	.56924	.78718E-03	-.21223E-02	1.0003	-.78927E-03	.17227E-02
45	4.9785	1.0000	.32826E-04	-.15546E-03	.56937	.38062E-03	-.10705E-02	1.0002	-.44171E-03	.10067E-02
46	5.2459	1.0000	.61678E-05	-.43941E-04	.56943	.17078E-03	-.49901E-03	1.0001	-.23303E-03	.55423E-03
47	5.5266	1.0000	0.	0.	.56946	.70735E-04	-.21377E-03	1.0000	-.11513E-03	.28572E-03
48	5.8214	1.0000	0.	0.	.56947	.26895E-04	-.83697E-04	1.0000	-.52866E-04	.13677E-03
49	6.1309	1.0000	0.	0.	.56948	.93344E-05	-.29782E-04	1.0000	-.22377E-04	.60257E-04
50	6.4559	1.0000	0.	0.	.56948	.29395E-05	-.95749E-05	1.0000	-.86537E-05	.24204E-04
51	6.7971	1.0000	0.	0.	.56948	.83452E-06	-.27637E-05	1.0000	-.30275E-05	.87735E-05
52	7.1553	1.0000	0.	0.	.56948	.21204E-06	-.71120E-06	1.0000	-.94763E-06	.26373E-05
53	7.5315	1.0000	0.	0.	.56948	.47828E-07	-.16187E-06	1.0000	-.26196E-06	.80809E-06
54	7.9265	1.0000	0.	0.	.56948	.94838E-08	-.32279E-07	1.0000	-.62975E-07	.19948E-06

22

55	8.3413	1.0000	0.	0.	.56948	.16339E-08	-.55751E-08	1.0000	-.12921E-07	.41902E-07
56	8.7767	1.0000	0.	0.	.56948	.24105E-09	-.82179E-09	1.0000	-.22003E-08	.73336E-08
57	9.2340	1.0000	0.	0.	.56948	.30118E-10	-.10079E-09	1.0000	-.29505E-09	.99990E-09
58	9.7141	1.0000	0.	0.	.56948	.29599E-11	-.12330E-10	1.0000	-.27505E-10	.11458E-09

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3. Malik, M. R. and Orszag, S. A., "Comparison of Methods for Prediction of Transition by Stability Analysis," AIAA J. 18, 1485-1489, 1980.

4. Srokowski, A. J. and Orszag, S. A., "Mass Flow Requirements for LFC Wing Design," AIAA paper 77-1222.

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6. Mack, L. M., "On the Stability of the Boundary Layer on a Transonic Swept Wing," AIAA Paper No. 79-0264.

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APPENDIXES

APPENDIX A

Listing of COSAL

```
      PROGRAM COSAL(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7)
C
C
C        ****************************************************
C        *                                                  *
C        *                                                  *
C        * COSAL--COMPRESSIBLE STABILITY ANALYSIS PROGRAM   *
C        *                      *                           *
C        *           SWEPT WING APPLICATIONS                *
C        *                      *                           *
C        *                                                  *
C        *                                                  *
C        ****************************************************
C
C
C     SUBROUTINE LU IS AVAILABLE IN FORTRAN OR COMPASS VERSION
C     USE OF COMPASS VERSIONS ON CDC MACHINES WILL IMPROVE CPU TIME
C
C     ********************NAMELIST INPUT INSTRUCTIONS*****************
C
C
C     NSTART        STATION NO. TO BEGIN CALCULATION FOR MULTIPLE STATION
C                   COMPUTATION
C     IBEGIN = 1    INPUT ALPHA AND BETA WILL BE USED TO MAKE WAVE NUMBER
C                   PROGRAM WILL PROCEED FROM STATION NSTART TO SEARCH
C                   FOR UNSTABLE MODE FOR WAVENUMBER OBTAINED FROM
C                   INPUT ALPHA AND BETA (SPECIFIED ONLY WITH ITRIV=1)
C                   IBLIND MUST BE SET TO ZERO IF IBEGIN IS SET TO ONE.
C                   AMPLIFICATION RATES WILL BE MAXIMIZED (ENVELOPE MET.)
C     IBEGIN = 0    DISABLES THE OPTION
C     IPSI = 0      DEFAULT STREAMWISE OR CRITICAL CROSSFLOW ANGLES WILL
C                   BE USED FOR UNSTABLE MODE SEARCH
C     IPSI = 1      USER INPUT ANGLE PSI WILL BE USED AS WAVE ANGLE FOR
C                   UNSTABLE MODE SEARCH
C     PSI =         WAVE ANGLE FOR UNSTABLE MODE SEARCH. (DEGREES)
C                   NPSI VALUES MAY BE INPUT.  FOR ITRIV=5 NPSI IS
C                   LIMITED TO 10. FOR ITRIV=1 OR 4 OR 6, NPSI IS LIMITED
C                   TO 1. SIGN OF PSI IS MEASURED POSITIVE IN A
C                   COUNTERCLOCKWISE DIRECTION FROM THE LOCAL FREE
C                   STREAM DIRECTION
C     NPSI =        NUMBER OF INPUT PSI VALUES  (LIMIT OF 10)
C     NSTOP =       STATION NUMBER TO END COMPUTATION
C     NINTEG = 0    NO INTEGRATION OF AMPLIFICATION RATES
C                   CALCULATIONS WILL BE PERFORMED ALONG AN ARC OF
C                   CONSTANT RADIUS
C     NINTEG = 1    AMPLIFICATION RATES WILL BE INTEGRATED
C                   ASSUMES ZERO AMPLITUDE AT LEADING EDGE
C     NINTEG = 2    AMPLIFICATION RATES WILL BE INTEGRATED
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C                       IF NR=0 THEN STARTING AMPLITUDE WILL BE TAKEN AS ZEROCOSAL
C                       AT STATION NUMBER = NZERO                            COSAL
C                       IF NR=1 THIS DENOTES A RESTART RUN                   COSAL
C                       WHICH MEANS THAT THE AMPLITUDE, REYNOLDS NUMBER,     COSAL
C                       AND DISPLACEMENT THICKNESS AT THE STARTING LOCATION  COSAL
C                       MUST BE INPUT FROM THE PREVIOUS RUN                  COSAL
C                       IF NR=2 THIS IS THE SAME AS (NR=0) EXCEPT THAT       COSAL
C                       NZERO IF SET INTERNALLY TO BE THE STATION IMMEDIATELYCOSAL
C                       BEFORE THE FIRST ONE FOR WHICH GOOD UNSTABLE MODES   COSAL
C                       ARE FOUND                                            COSAL
C       NR = 0          NOT A RESTART                                        COSAL
C       NR = 1          THIS IS A RESTART RUN                                COSAL
C                       NOTE: NR=1 RESTART OPTION CAN ONLY BE USED FOR       COSAL
C                       ITRIV=1 WITH NINTEG=2                                COSAL
C       NR = 2          NOT A RESTART                                        COSAL
C       NWANT =         NUMBER OF STATION TO BE INPUT IF SOLUTION DESIRED AT COSAL
C                       ONE STATION ONLY                                     COSAL
C       NSTAT = 0       ONLY ONE STATION DESIRED  (NWANT MUST BE INPUT)      COSAL
C                       SET FOR ITRIV .EQ. 0                                 COSAL
C       NSTAT = 1       MORE THAN ONE STATION DESIRED                        COSAL
C                       NSTART AND NSTOP MUST BE INPUT                       COSAL
C                       SET FOR ITRIV .NE. 0                                 COSAL
C       IBLIND          IF ITRIV = 1 IS USED, THEN IBLIND MUST BE INPUT.     COSAL
C                   = 0 AT STATION NSTART, AN ALPHA BETA COMBINATION THAT    COSAL
C                       YIELDS A GOOD UNSTABLE MODE IS KNOWN.  THIS ALPHA ANDCOSAL
C                       BETA COMBINATION MUST BE INPUT.                      COSAL
C                       IF IBEGIN IS SET TO ONE, AND IBLIND IS SET TO ZERO,  COSAL
C                       PROGRAM WILL EXECUTE AS DESCRIBED UNDER IBEGIN = 1.  COSAL
C                   = 1 ALPHA AND BETA FOR UNSTABLE MODE IS NOT KNOWN.  USER COSAL
C                       SHOULD INPUT RANGE OF XLENC AND SPECIFY VALUE OF PSI COSAL
C                       (INPUT OR DEFAULT). PROGRAM WILL SEARCH FOR UNSTABLE COSAL
C                       MODES AUTOMATICALLY WITHIN THE SPECIFIED PSI-XLENC   COSAL
C                       MATRIX                                               COSAL
C                       IF IBLIND = 1 IS SELECTED, IBEGIN MUST BE SET TO ZEROCOSAL
C       ITRIV = 0       SIMPLE EIGENVALUE COMPUTATION AT ONE STATION (NSTAT=0COSAL
C                       NWANT MUST BE GIVEN)                                 COSAL
C                       IAB PARAMETER MUST BE SET TO EXECUTE DESIRED OPTION. COSAL
C       ITRIV = 1       SEARCH PROCEDURES TO MAXIMIZE AMPLIFICATION WILL     COSAL
C                       BE IMPLEMENTED.  (FREQUENCY FIXED)                   COSAL
C                       IBLIND MUST BE SET TO 0 OR 1 (SEE INSTRUCTIONS FOR   COSAL
C                       IBLIND)                                              COSAL
C       ITRIV =2; 3     INOPERATIVE                                          COSAL
C       ITRIV = 4       PROGRAM WILL FOLLOW AND INTEGRATE N FACTORS FOR A    COSAL
C                       DISTURBANCE OF FIXED WAVELENGTH AND ORIENTATION.     COSAL
C                       (RELATIVE TO LOCAL FREE STREAM DIRECTION). FREQUENCY COSAL
C                       OF THE DISTURBANCE CHANGES.                          COSAL
C                       AMPLIFICATION RATES ARE NOT MAXIMIZED.               COSAL
C                       ONLY ONE VALUE OF PSI AND XLENC MAY BE INPUT.        COSAL
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C                   NPSI AND NXLEN MUST BE SET TO 1.                   COSAL
C                   IF IPSI = 0, DEFAULT CRITICAL CROSSFLOW ANGLE      COSAL
C                   OBTAINED AT STATION NSTART WILL BE FOLLOWED ALL THE COSAL
C                   WAY THROUGH.                                       COSAL
C     ITRIV = 5     PROGRAM WILL FOLLOW AND INTEGRATE N FACTORS FOR A  COSAL
C                   DISTURBANCE OF FIXED WAVELENGTH AND FREQUENCY.     COSAL
C                   ORIENTATION OF THE DISTURBANCE CHANGES.            COSAL
C                   AMPLIFICATION RATES ARE NOT MAXIMIZED.             COSAL
C     ITRIV = 6     PROGRAM WILL FOLLOW AND INTEGRATE N FACTORS FOR A  COSAL
C                   DISTURBANCE OF FIXED ORIENTATION AND FREQUENCY.    COSAL
C                   DISTURBANCE WAVELENGTH CHANGES.                    COSAL
C     IAB = 0       INPUT ALPHA AND BETA WILL BE USED FOR SIMPLE       COSAL
C                   EIGENVALUE COMPUTATION                             COSAL
C     IAB = 1       STRING OF INPUT ALPHA,BETA PAIRS WILL BE USED FOR A COSAL
C                   STRING OF SIMPLE EIGENVALUE COMPUTATIONS           COSAL
C                   LIMIT OF 10 (INPUT THROUGH ALPX,BETX ARRAYS)       COSAL
C     IAB = 2       ONE INPUT WAVELENGTH TO CHORD (XLENC) VALUE WILL BE COSAL
C                   USED WITH INPUT VALUES OF PSI FOR A STRING OF SIMPLE COSAL
C                   EIGENVALUE COMPUTATIONS (LIMIT OF 10 PSI VALUES)   COSAL
C                   ALPHA AND BETA WILL THEN BE COMPUTED BY THE PROGRAM COSAL
C                   ITRIV = 0 NEEDS TO BE INPUT FOR ANY OF THE IAB     COSAL
C                   OPTIONS TO BE EXECUTED  (NPSI NEEDS TO BE INPUT)   COSAL
C     NZERO =       NUMBER OF STATION AT WHICH STARTING AMPLITUDE IS TO COSAL
C                   BE ASSUMED EQUAL TO ZERO                           COSAL
C                   INPUT ONLY IF NR = 0 .                             COSAL
C     NAB =         NUMBER OF ALPHA AND BETA PAIRS.  (ALPX AND BETX)   COSAL
C                   (LIMIT OF 10)                                      COSAL
C     ITYP = 0      CROSSFLOW COMPUTATION                              COSAL
C     ITYP = 1      T-S COMPUTATION                                    COSAL
C                   ITYP SHOULD ALWAYS BE SPECIFIED                    COSAL
C     ICON = 0      PROGRAM WILL TERMINATE COMPUTATION UPON ENCOUNTERING COSAL
C                   FIRST STABLE REGION                                COSAL
C     ICON = 1      PROGRAM WILL CONTINUE THRU FIRST STABLE REGION AND COSAL
C                   WILL PICK UP COMPUTING A SECOND UNSTABLE ZONE, IF ONECOSAL
C                   EXISTS. PROGRAM WILL TERMINATE UPON ENCOUNTERING   COSAL
C                   SECOND STABLE REGION. N FACTOR WILL BE RESET TO ZERO COSAL
C                   UPON ENCOUNTERING SECOND UNSTABLE ZONE             COSAL
C     ICON = 2      PROGRAM WILL COMPUTE THROUGH ALL STABLE-UNSTABLE   COSAL
C                   REGIONS.                                           COSAL
C     NXLEN =       NUMBER OF INPUT VALUES OF XLENC                    COSAL
C                   GENERALLY A MAXIMUM OF 5 ALLOWED EXCEPT THAT IF    COSAL
C                   ( ITRIV =0;4  :LIMITED TO 1 )                      COSAL
C                   (ITRIV = 5; LIMITED TO 1), (ITRIV=6; LIMITED       COSAL
C                   TO 5))                                             COSAL
C     XLENC =       RATIO OF WAVELENGTH TO CHORD                       COSAL
C     RFREQ =       PHYSICAL FREQUENCY OF THE DISTURBANCE WHICH        COSAL
C                   COSAL IS TO FOLLOW (HERTZ)                         COSAL
C     IPR'S SET TO 0  WILL DISABLE THE PRINTS                          COSAL
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C      IPP1 = 1      MEAN FLOW PROFILES PRINTED AS SUPPLIED BY TAPE 7     COSAL     145
C      IPP2 = 1      EIGENVALUE SPECTRUM FROM GLOBAL CALCULATION          COSAL     146
C                    WILL BE PRINTED                                      COSAL     147
C      IPP3 = 1      LOCAL EIGENVALUE ITERATION PRINTED                   COSAL     148
C      IPP4 = 1      EIGENFUNCTION WILL BE PRINTED, (M MUST BE 5)         COSAL     149
C      IPP5 = 1      MEAN FLOW PROFILES INTERPOLATED TO COMPUTATIONAL     COSAL     150
C                    GRID WILL BE PRINTED                                 COSAL     151
C      IPP7 = 1      INTERMEDIATE ITERATION RESULTS WILL BE PRINTED       COSAL     152
C      MG = 4        GLOBAL EIGENVALUE SEARCH WILL BE PERFORMED USING     COSAL     153
C                    6TH ORDER SYSTEM                                     COSAL     154
C      MG = 5        GLOBAL EIGENVALUE SEARCH WILL BE PERFORMED USING     COSAL     155
C                    8TH ORDER SYSTEM                                     COSAL     156
C      NG =          NUMBER OF NODE POINTS USED IN GLOBAL EIGENVALUE      COSAL     157
C                    SEARCH, ( (NG-1)*MG).LE.NDIM )                       COSAL     158
C      M = 4         LOCAL EIGENVALUE SEARCH WILL BE PERFORMED USING      COSAL     159
C                    6TH ORDER SYSTEM                                     COSAL     160
C      M = 5         LOCAL EIGENVALUE SEARCH WILL BE PERFORMED USING      COSAL     161
C                    8TH ORDER SYSTEM                                     COSAL     162
C      NCHEB =       NUMBER OF NODE POINTS TO BE USED IN LOCAL EIGENVALUE COSAL     163
C                    SEARCH, (FOR MAXIMUM ALLOWABLE NCHEB, SEE IPRZ)      COSAL     164
C      ICHEB = 0     NCHEB NODE POINTS WILL BE USED IN LOCAL SEARCH       COSAL     165
C                    AND INCREASED TO SATISFY ACCURACY TESTS              COSAL     166
C      ICHEB = 1     DEFAULT NUMBER OF NODE POINTS WILL BE USED AND       COSAL     167
C                    INCREASED TO SATISFY ACCURACY TESTS                  COSAL     168
C      ICHEB = 2     NCHEB NODE POINTS WILL BE USED FOR ALL STATIONS      COSAL     169
C                    AND NOT CHANGED                                      COSAL     170
C      IPPZ          RICHARDSON'S EXTRAPOLATION WILL BE USED TO           COSAL     171
C                    INCREASE THE ACCURACY OF LOCAL EIGENVALUE AND        COSAL     172
C                    GROUP VELOCITY USING NCHEB, (NCHEB+IPRZ), AND        COSAL     173
C                    (NCHEB+2*IPPZ) POINTS, ( (NCHEB+2*IPPZ).LE.101) )    COSAL     174
C      IPPZ = 0      NO EXTRAPOLATION USED, LOCAL EIGENVALUE AND GROUP    COSAL     175
C                    VELOCITY CALCULATED USING NCHEB (.LE.101) POINTS     COSAL     176
C      YEDGE         EDGE OF THE BOUNDARY LAYER FOR STABILITY CALCULA-    COSAL     177
C                    TIONS, (DISTANCE NORMAL TO SOLID BOUNDARY/DISPLACE-  COSAL     178
C                    MENT THICKNESS). A RELATIVELY LARGE YEDGE IS NEEDED  COSAL     179
C                    SINCE DISTURBANCES ARE ASSUMED TO VANISH AT THE      COSAL     180
C                    OUTER BOUNDARY IN GLOBAL EIGENVALUE SEARCH. ( IN     COSAL     181
C                    LOCAL CALCULATIONS, HOWEVER, ASYMPTOTIC B.C. ARE     COSAL     182
C                    IMPOSED AT THE OUTER BOUNDARY). THE DEFAULT VALUE    COSAL     183
C                    WILL BE ADEQUATE IN MOST SITUATIONS.                 COSAL     184
C                                                                         COSAL     185
C     $$$$$$$$$$$$$$$$$$DEFAULT VALUES$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$  COSAL     186
C                                                                         COSAL     187
C     THE FOLLOWING DEFAULT VALUES WILL BE SET UNLESS CHANGED BY          COSAL     188
C     NAMELIST INPUT                                                      COSAL     189
C     IPLIND = 1, NCHEB = 21, NINTEG = 2, ITYP = 0, IBEGIN = 0, NR = 2,   COSAL     190
C     NSTAT = 1, ITPIV = 5, PEREO = .5, ICHEB = 2, IAB = 0, NAB = 0,      COSAL     191
C     IPP1 THRU IPR7 = 0, NZERO = 2, ICON = 1, IPSI = 0, XLENC = .0005,   COSAL     192
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C     NPSI = 1, NXLEN = 1. PSI = 0.0, NWANT = 0, NSTART=0, NSTOP=0,
C     MG=4, NG=21, M=5, IPRZ=10, YEDGE=100.
C
C
C      $$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
C
C
C              *********PHYSICAL PARAMETERS***********
C      THE FOLLOWING VALUES OF THE PHYSICAL PARAMETERS WILL BE SET
C      UNLESS CHANGED IN THE DATA STATEMENT
C      PRANDTL = 0.72         (PRANDTL NUMBER)
C      GAMA    = 1.4          (RATIO OF SPECIFIC HEATS)
C      STOKES  = 1.2          (RATIO OF SECOND COEFFICIENT OF VISCOSITY
C                                TO THE FIRST)
C
C                             (FIRST COEFFICIENT OF VISCOSITY IS
C                                CALCULATED USING SUTHERLAND'S LAW)
C
C
C      ********************START COSAL CODE******************************
       REAL MUE,MACH
        DIMENSION UE(60),THETA(60),XC(60),TITLE(20)
       DIMENSION XS(102),US(102),US1(102),US2(102),WS(102),
     1 WS1(102),WS2(102),TS(102),TS1(102),TS2(102)
       DIMENSION YM(102),UM(102),UM1(102),UM2(102),WM(102),
     1 WM1(102),WM2(102),TM(102),TM1(102),TM2(102)
       DIMENSION WORK(101)
       COMPLEX FOUV1(2020)
       DIMENSION FOV1(1020)
       DIMENSION EOV2(1020)
       COMPLEX A(5,5,101),B(5,5,101),AA(5,5,101),BB(5,5,101),CC(5,5,101),
     1 UU(5,101),UWRK(5,101),VV(5,101),VWRK(5,101)
       DIMENSION IP(5,101),IC(5,101),XX(101),CSP(101)
       COMPLEX WORKC(320)
C
C
C     DIMENSIONING FOR GLOBAL EIGENVALUE PROBLEM
C
C
       COMPLEX AC(100,100),EIGA(100)
C
C
C       ORDER OF AC CAN BE ICREASED TO 160 (NDIM IN THE DATA STATEMENT
C                             WILL HAVE TO BE CHANGED ACCORDINGLY).
C       THIS CARD WILL THEN READ :
C
C       COMPLEX AC(160,160),EIGA(160)
C
```

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C
C
      COMPLEX XLAM,XLAM1,XLAM2,VA,VB,VA1,VB1,VA2,VB2
      COMPLEX DWDS,XLAMA
      DIMENSION ALPX(10), BETX(10)
      DIMENSION  PSI(10)
      DIMENSION XLEN(5), XLENC(5)
      COMMON AC
      COMMON /MFLD/ KPTS,Y(102),U(102),U1(102),U2(102),W(102),
     1 W1(102),W2(102),T(102),T1(102),T2(102)
      COMMON /PROP/ XMACH,GAMA,REY,PRANDTL,STOKES,DSTZ
      COMMON /XMM/ MACH
      COMMON /GG/ G,XL,XX
      COMMON /MAP/ YEDGE
      COMMON /LOCAL/ LLL,NPASS,INTRPOL,IPR7
      COMMON /EDGE/ TE,MUE,UE
      COMMON /DUMWRK/ SAVE1(640)
      COMMON /GLOBE/ ILOC
      COMMON /FUN/ JPASS
      COMMON /IGLOB/ IGLOB
      COMMON /WING/ XC,THETA
      COMMON /OPTSTS/ G1,G2,H,HN
      COMMON /PRINTS/ IPR1,IPR2,IPR3,IPR4,IPR5,IPR6,IPR7
      EQUIVALENCE (XLEN,XLENC)
      EQUIVALENCE (ALPX(1),VA1), (ALPX(3),VB1), (ALPX(5),VA2), (ALPX(7),
     1VB2), (ALPX(9),XLAM1), (BETX(1),XLAM2), (BETX(3),DWDS), (BETX(5),X
     2LAMA), (BETX(7),ALPHA1), (BETX(8),ALPHA2), (BETX(9),BETA1), (BETX(
     310),BETA2)
C  IT IS ASSUMED WHILE EQUIVALENCING THAT 160 POINTS AT BEST CAN
C  BE USED FOR LOCAL SEARCH
      EQUIVALENCE (A(1),AC(1)),(B(1),AC(2526)),(EQUV1(1),AC(5051)),
     1 (EQV1(1),AC(7071)),(EQV2(1),AC(8091))
      EQUIVALENCE (UU(1),EQUV1(1)),(UWRK(1),EQUV1(506)),
     1 (VV(1),EQUV1(1011)),(VWRK(1),EQUV1(1516))
      EQUIVALENCE (XS(1),EQV1(1)),(US(1),EQV1(103)),(US1(1),EQV1(205)),
     1 (US2(1),EQV1(307)),(WS(1),EQV1(409)),(WS1(1),EQV1(511)),
     2 (WS2(1),EQV1(613)),(TS(1),EQV1(715)),(TS1(1),EQV1(817)),
     3 (TS2(1),EQV1(919))
      EQUIVALENCE (XM(1),EQV2(1)),(UM(1),EQV2(103)),(UM1(1),EQV2(205)),
     1 (UM2(1),EQV2(307)),(WM(1),EQV2(409)),(WM1(1),EQV2(511)),
     2 (WM2(1),EQV2(613)),(TM(1),EQV2(715)),(TM1(1),EQV2(817)),
     3 (TM2(1),EQV2(919))
      EQUIVALENCE (SAVE1(1),WORKC(1))
      NAMELIST /CARDIN/ NSTART,IBLIND,NSTOP,NINTEG,ITYP,IBEGIN,NP,
     1NWANT,NSTAT,ITRIV,RFREQ,ALPHA,BETA,IAB,NAB,ALPX,BETX,IPR1,IP
     2R2,IPR3,IPR4,IPR5,IPR7,NZERO,REYIN,RADIN,DSTZIN,XNIN,ICON,IPSI,PSI
     3,XLENC,NPSI,NXLEN,MG,NG,M,NCHEB,ICHEB,IPRZ,YEDGE
      DATA IBEGIN/0/,IBLIND/1/,NINTEG/2/,NP/2/,NSTAT/1/,IGLOB/1/,ITRIV/5
     )
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     1/,IAB/0/,NZERO/2/,NAB/0/,ITYP/0/,ICON/1/,IPR1/0/,IPR2/0/,IPR3/0/,ICOSAL
     2PR4/0/,IPR5/0/,IPR6/1/,IPR7/0/,IPSI/0/,EPS/1.E-5/,JTOP/1/,ITOP/1/,COSAL
     3NCHEB/21/,ICHEB/2/,FROTOL/.005/,NPSI/1/,XLENC/0.5E-3,4*0.0/,JPASS/COSAL
     40/,ITRIP/0/,NDIM/100/,ICOUNT/0/,REYIN/0./,RADIN/0./,DSTZIN/0./,    COSAL
     5XNIN/0./,RFREQ/0.5/,NXLEN/1/,PSI/10*0.0/,NWANT/0/,NPOS/0/,         COSAL
     6IPR7/10/,PRANDTL/.72/,STOKES/0.8/,GAMA/1.4/,YEDGE/100./,M/5/,      COSAL
     7 MG/4/,INTRPOL/0/,LLL/10/,NPASS/2/,NG/21/,NSTART/0/,NSTOP/0/,      COSAL
     8 ALPHA/0./,BETA/0./,ALPX/10*0./,BETX/10*0./                        COSAL
C      -------READ CARDS                                                 COSAL
       READ (5,CARDIN)                                                   COSAL
       IF(IPR7.EQ.0)INTRPOL=1                                            COSAL
       NC=NCHEB                                                          COSAL
       IF(ICHEB.EQ.1)NC=21                                               COSAL
       IF (ITRIV.EQ.4) IGLOB=2                                           COSAL
       IF (IBEGIN.EQ.1) WAVE=SQRT(ALPHA**2+BETA**2)                      COSAL
       WRITE (6,CARDIN)                                                  COSAL
       READ (7) TITLE                                                    COSAL
       READ (7) NZT,RADIUS,CHORD                                         COSAL
       WRITE (6,143)                                                     COSAL
       WRITE (6,133) TITLE                                               COSAL
       WRITE(6,159)CHORD                                                 COSAL
       WRITE (6,143)                                                     COSAL
C      *****INPUT CHECKS****                                             COSAL
       IF (IBEGIN.EQ.1.AND.ITRIV.NE.1) CALL CHECK (50HIBEGIN---ITRIV CONFCOSAL
     1LICT                                 )                             COSAL
       IF (NR.EQ.1.AND.(IBEGIN.NE.0.OR.IBLIND.NE.0)) CALL CHECK (50HNR = COSAL
     11----IBLIND OR IBEGIN CONFLICT                  )                  COSAL
       IF (IBEGIN.EQ.1.AND.IBLIND.EQ.1) CALL CHECK (50HIBLIND-IBEGIN CONFCOSAL
     1LICT                                 )                             COSAL
       IF (NSTAT.EQ.0.AND.NWANT.EQ.0.AND.ITRIV.EQ.0) CALL CHECK (50HNSTATCOSAL
     1-NWANT CONFLICT                                  )                 COSAL
       IF (NSTAT.EQ.1.AND.NSTART.LT.2) CALL CHECK (50HNSTART NOT SET PROPCOSAL
     1ERLY                                 )                             COSAL
       IF (ITRIV.EQ.0.AND.NSTAT.NE.0) CALL CHECK (50HITRIV=0--NSTAT CONFLCOSAL
     1ICT                                  )                             COSAL
       IF (ITRIV.EQ.2.OR.ITRIV.EQ.3) CALL CHECK (50HINOPERATIVE ITRIV VALCOSAL
     1UE SELECTED                          )                             COSAL
       IF (ITRIV.EQ.1.AND.(IBLIND.NE.0.AND.IBLIND.NE.1)) CALL CHECK (50HICOSAL
     1BLIND-ITRIV CONFLICT                             )                 COSAL
       IF (ITRIV.EQ.4.AND.(NPSI.NE.1.OR.NXLEN.NE.1)) CALL CHECK (50HITRIVCOSAL
     1=4--NXLEN OR NPSI CONFLICT                       )                 COSAL
       IF (NPSI.GT.10.OR.NXLEN.GT.5.OR.NAB.GT.10) CALL CHECK (50HNPSI,NXLCOSAL
     1EN,OR NAB IS TOO LARGE                       )                     COSAL
       IF (ITRIV.NE.0.AND.NSTAT.EQ.0) CALL CHECK (50HNSTAT=0--ITRIV CONFLCOSAL
     1ICT                                  )                             COSAL
       NPR=NCHEB+2*IPR7                                                  COSAL
       NGP=(NG-1)*MG                                                     COSAL
       IF(NPR.GT.101)CALL CHECK(50HTOO MANY NODE POINTS FOR LOCAL SEARCH COSAL
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      1            )                                                    COSAL     337
       IF(NGR.GT.160)CALL CHECK(50HTOO MANY NODE POINTS FOR GLOBAL SEARCHCOSAL     338
      1             )                                                   COSAL     339
C     *****************************                                     COSAL     340
C     ------READ NO OF STATIONS IN FILE                                 COSAL     341
      WRITE (6,129)                                                     COSAL     342
      IF (NXLEN.EQ.0) GO TO 2                                           COSAL     343
      DO 1 I=1,NXLEN                                                    COSAL     344
1     XLEN(I)=XLENC(I)*CHORD                                            COSAL     345
2     CONTINUE                                                          COSAL     346
C     -----READ WING GEOMETRY AND INVISCID VALUES                       COSAL     347
      CALL WING (NZT)                                                   COSAL     348
C     ------CHECK IF SIMPLE EIGENVALUE COMPUTATION REQUIRED             COSAL     349
      IF (ITRIV.NE.0) GO TO 7                                           COSAL     350
C     ***** ITRIV = 0 OPTION                                            COSAL     351
C     -----INPUT APPROPRIATE PROFILE                                    COSAL     352
      CALL FLOW(NWANT,NZ)                                               COSAL     353
      CALL MAKXLG                                                       COSAL     354
      I=1                                                               COSAL     355
      IF (IAB.EQ.0) GO TO 5                                             COSAL     356
      IF (IAB.NE.2) GO TO 4                                             COSAL     357
C     *****IAB = 2 OPTION                                               COSAL     358
      NAB=NPSI                                                          COSAL     359
      PHI=ATAN(W(KPTS)/U(KPTS))                                         COSAL     360
      WWV=2.*3.14159*DSTZ/XLEN(1)                                       COSAL     361
      DO 3 J=1,NAB                                                      COSAL     362
      ALPX(J)=WWV*COS(PSI(J)/57.29577+PHI)                              COSAL     363
3     BETX(J)=WWV*SIN(PSI(J)/57.29577+PHI)                              COSAL     364
C     *****IAB = 1 OPTION                                               COSAL     365
4     CONTINUE                                                          COSAL     366
      ALPHA=ALPX(I)                                                     COSAL     367
      BETA=BETX(I)                                                      COSAL     368
5     CONTINUE                                                          COSAL     369
C     ****** IAB = 0 OPTION                                             COSAL     370
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,          COSAL     371
     1 ALPHA,BETA,XLAM,CSP)                                             COSAL     372
      CALL LOCAL(A,B,AA,BB,CC,UU,UWPK,VV,VWRK,M,NC,IR,IC,               COSAL     373
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)                                  COSAL     374
      WRITE (6,128) NWANT,XC(NWANT),NC,REY,MACH                         COSAL     375
      IF (IAB.EQ.2) WRITE (6,105) XLEN(1)/CHORD,PSI(I)                  COSAL     376
      WRITE (6,130) ALPHA,BETA,XLAM                                     COSAL     377
      WRITE (6,131)                                                     COSAL     378
      WRITE(6,132) VA,VB                                                COSAL     379
      IF (IAB.EQ.0) GO TO 6                                             COSAL     380
      I=I+1                                                             COSAL     381
      JPASS=0                                                           COSAL     382
      IF(I.GT.NAB)GO TO 6                                               COSAL     383
      GO TO 4                                                           COSAL     384
     )
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 6    CONTINUE
      CALL EXIT
C     ****** END OF ITRIV = 0 OPTION
 7    CONTINUE
C     -------CHECK IF DEFAULT ANGLES WANTED
      IF (IPSI.EQ.0) GO TO 9
      DO 8 I=1,NPSI
 8    PSI(I)=PSI(I)/57.29577
 9    CONTINUE
C     ------ENVELOPE METHOD BYPASS
      IF (ITRIV.EQ.4.OR.ITRIV.EQ.5.OR.ITRIV.EQ.6) GO TO 11
C     *****IBLIND, ITRIV = 1 BRANCH
      IF (IBLIND.NE.0) GO TO 11
10    CONTINUE
      IF (NSTAT.EQ.0) NDUM=NWANT
      IF (NSTAT.EQ.1) NDUM=NSTART
      CALL FLOW(NDUM,NZ)
      GO TO 39
11    CONTINUE
C      ITRIV  =  4; 5; 6   STARTUP LOOP
C     ***** ITRIV = 1 WITH IBLIND = 1 STARTUP LOOP
      IF (IBEGIN.EQ.0.OR.ITRIP.EQ.0) GO TO 12
      ITRIP=0
      IBEGIN=0
      IPSI=1
      PSI(1)=PSISAV
      XLEN(1)=XLENSAV
12    CONTINUE
C     ***** READ PROFILE, COMPUTE CRITICAL CROSSFLOW ANGLE IF NEEDED
      CALL FLOW(NSTART,NZ)
      PHI=ATAN(W(KPTS)/U(KPTS))
      IF (ITRIV.EQ.1.AND.ITYP.EQ.0.AND.IPSI.EQ.0) GO TO 13
      IF (ITRIV.NE.5.OR.ITYP.NE.0.OR.ICOUNT.EQ.0) GO TO 14
13    CONTINUE
      CALL CRIT (PSICRIT)
      PSI(1)=PSICRIT-PHI
      NPSI=1
14    CONTINUE
      IF (NZ.GT.NSTOP) CALL EXIT
      IF (NR.NE.1) GO TO 15
C     ***** RESTART INITIALIZATION
      XN=XNIN
      DSTZ=DSTZIN
      REY=REYIN
15    CONTINUE
      CALL MAKXLG
      IF (IPSI.EQ.1.OR.ICOUNT.NE.0) GO TO 16
      NPSI=1
```

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C     ***** ANGLE COMPUTATIONS                                           COSAL
      IF (ITYP.EQ.0) CALL CPIT (PSICRIT)                                 COSAL
      IF (ITYP.EQ.0) PSI(1)=PSICRIT-PHI                                  COSAL
      IF (ITYP.EQ.1) PSI(1)=ATAN(W(KPTS)/U(KPTS))-PHI                    COSAL
16    CONTINUE                                                           COSAL
      IF (ITRIV.EQ.6.OR.ITRIV.EQ.1) GO TO 20                             COSAL
C     ***** ITRIV = 4;5 INITIAL STATION UNSTABLE MODE SEARCH             COSAL
      WWV=2.*3.14159*DSTZ/XLEN(1)                                        COSAL
      DO 19 I=1,NPSI                                                     COSAL
      ALPHA=WWV*COS(PSI(I)+PHI)                                          COSAL
      BETA=WWV*SIN(PSI(I)+PHI)                                           COSAL
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,           COSAL
     1 ALPHA,BETA,XLAM,CSP)                                              COSAL
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,                COSAL
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)                                   COSAL
      IF (ITRIV.EQ.4) WRITE (6,152) XLEN(1)/CHORD,PSI(I)*57.29577,NZ,PHICOSAL
     1*57.29577,ALPHA,BETA,XLAM                                          COSAL
      IF (ITRIV.EQ.5) WRITE (6,106) NZ,XLEN(1)/CHORD,PSI(I)*57.29577,PHICOSAL
     1*57.29577                                                          COSAL
C     *****CHECK ACCURACY,SIGN OF IMAGINARY PART OF OMEGA                COSAL
      IF (AIMAG(XLAM).LT.0.0) GO TO 18                                   COSAL
      ISAVE=I                                                            COSAL
      GO TO 20                                                           COSAL
18    CONTINUE                                                           COSAL
      IF (ITRIV.EQ.4) WRITE (6,149) NZ,XLEN(1)/CHORD,PSI(I)*57.29577     COSAL
      IF (ITRIV.EQ.5) WRITE (6,150) NZ,XLEN(1)/CHORD,PSI(I)*57.29577     COSAL
19    CONTINUE                                                           COSAL
      GO TO 11                                                           COSAL
C     ***** LOOP BACK AND READ NEXT STATION IF NO INSTABILITY FOUND      COSAL
20    CONTINUE                                                           COSAL
      JPASS=0                                                            COSAL
      IF (ITRIV.NE.6.AND.ITRIV.NE.1) GO TO 31                            COSAL
C     ***** ITRIV =1;6 INITIAL STATION UNSTABLE MODE SEARCH              COSAL
      DO 23 I=1,NXLEN                                                    COSAL
      WWV=2.*3.14159*DSTZ/XLEN(I)                                        COSAL
      ALPHA=WWV*COS(PSI(1)+PHI)                                          COSAL
      BETA=WWV*SIN(PSI(1)+PHI)                                           COSAL
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,           COSAL
     1 ALPHA,BETA,XLAM,CSP)                                              COSAL
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,                COSAL
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)                                   COSAL
      WRITE (6,107) ITRIV,NZ,PSI(1)*57.29577,XLEN(I)/CHORD               COSAL
      WRITE (6,130) ALPHA,BETA,XLAM                                      COSAL
C     *****CHECK ACCURACY AND SIGN                                       COSAL
      IF (AIMAG(XLAM).LT.0.0) GO TO 22                                   COSAL
      ISAV=I                                                             COSAL
      GO TO 24                                                           COSAL
22    CONTINUE                                                           COSAL
```

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23    CONTINUE
      WRITE (6,108) ITRIV,NZ
C     ***** LOOP BACK AND READ NEXT STATION IF NO INSTABILITY FOUND
      GO TO 11
24    CONTINUE
      IF (ITRIV.EQ.1) GO TO 41
      WWV1=WWV
      NUMB=0
      FREQ=XMFRQ(RFREQ,UE(NZ),DSTZ)
      GO TO 26
C     ***** ITRIV = 6 INITIAL STATION CONVERGENCE LOOP ON DESIRED
C     ***** FREQUENCY
 25   CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA,BETA,XLAM,CSP)
26    CONTINUE
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)
      IF (IPR7.EQ.0) GO TO 28
      WRITE (6,109) NUMB,XLEN(ISAV)/CHORD,PSI(1)*57.29577
      WRITE (6,127) ALPHA,BETA,XLAM,VA,VB
28    CONTINUE
      IF (NUMB.GT.7) WRITE (6,110) ITRIV,RFREQ,NZ
C     ***** CHECK ACCURACY,SIGN, AND LOOP BACK TO NEXT STATION IF
C     ***** STABLE MODE FOUND
      IF (NUMB.GT.7) GO TO 11
      IF ((ABS((FREQ-REAL(XLAM))/FREQ).LE.FROTOL).AND.AIMAG(XLAM).GT.0.0
     1) GO TO 30
      IF ((ABS((FREQ-REAL(XLAM))/FREQ).LE.FROTOL).AND.AIMAG(XLAM).LT.0.0
     1) WRITE (6,110) ITRIV,RFREQ,NZ
      IF ((ABS((FREQ-REAL(XLAM))/FREQ).LE.FROTOL).AND.AIMAG(XLAM).LT.0.0
     1) GO TO 11
C     ***** COMPUTE WAVENUMBER CHANGE
      DLAM=REAL(VA)*COS(PSI(1)+PHI)+REAL(VB)*SIN(PSI(1)+PHI)
      WWV=WWV1-(REAL(XLAM)-FREQ)/DLAM
      IF (NUMB.GT.4) GO TO 29
C     ****** LIMIT WAVENUMBER EXCURSIONS
      IF (WWV.LT.0.7*WWV1) WWV=.7*WWV1
      IF (WWV.GT.1.3*WWV1) WWV=1.3*WWV1
29    CONTINUE
C     ***** INCREMENT LOOP COUNTERS, RESETS, AND COMPUTE NEW ALPHA ,BETA
      NUMB=NUMB+1
      A1=ALPHA
      B1=BETA
      WWV1=WWV
      ALPHA=WWV*COS(PSI(1)+PHI)
      BETA=WWV*SIN(PSI(1)+PHI)
C     ***** REFINE LOCAL METHOD GUESS
      XLAM=XLAM+VA*(ALPHA-A1)+VB*(BETA-B1)
```

```
      IF (JPASS.NE.0) GO TO 26                                          COSAL
      GO TO 25                                                          COSAL
   30 CONTINUE                                                          COSAL
C     ***** RECOMPUTE XLEN AND SAVE                                     COSAL
      XLEN(1)=2.*3.14159*DSTZ/WWV                                       COSAL
      XLENSAV=XLEN(1)                                                   COSAL
      PSISAV=PSI(1)                                                     COSAL
      NXLEN=1                                                           COSAL
      NPSI=1                                                            COSAL
   31 CONTINUE                                                          COSAL
      IF (ITRIV.NE.5) GO TO 38                                          COSAL
C     ***** ITRIV = 5 INITIAL STATION CONVERGENCE LOOP ON DESIRED       COSAL
C     ***** FREQUENCY                                                   COSAL
C     ***** COMPUTE NONDIMENSIONAL FREQUENCY AND WAVE ANGLE WITH RESPECTCOSAL
C     ***** TO ALPHA AXIS                                               COSAL
      FREQ=XMFRQ(RFREQ,UE(NZ),DSTZ)                                     COSAL
      PSID=PSI(ISAVE)+PHI                                               COSAL
      NUMB=0                                                            COSAL
      PSID1=PSID                                                        COSAL
      GO TO 33                                                          COSAL
   32 CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,          COSAL
     1 ALPHA,BETA,XLAM,CSP)                                             COSAL
   33 CONTINUE                                                          COSAL
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,               COSAL
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)                                  COSAL
      IF (IPR7.EQ.0) GO TO 35                                           COSAL
      WRITE (6,111) NUMB,PSID*57.29577                                  COSAL
      WRITE (6,127) ALPHA,BETA,XLAM,VA,VB                               COSAL
   35 CONTINUE                                                          COSAL
      IF (NUMB.GT.7) WRITE (6,112) RFREQ,NZ                             COSAL
C     ***** TESTS                                                       COSAL
      IF (NUMB.GT.7) GO TO 11                                           COSAL
      IF ((ABS((FREQ-REAL(XLAM))/FREQ).LE.FROTOL).AND.AIMAG(XLAM).GT.0.0COSAL
     1) GO TO 37                                                        COSAL
      IF ((ABS((FREQ-REAL(XLAM))/FREQ).LE.FROTOL).AND.AIMAG(XLAM).LT.0.0COSAL
     1) WRITE (6,112) RFREQ,NZ                                          COSAL
      IF ((ABS((FREQ-REAL(XLAM))/FREQ).LE.FROTOL).AND.AIMAG(XLAM).LT.0.0COSAL
     1) GO TO 11                                                        COSAL
C     ***** COMPUTE CHANGE IN ORIENTATION ANGLE                         COSAL
      DZI=WWV*(COS(PSID)*REAL(VB)-SIN(PSID)*REAL(VA))                   COSAL
      PSID=PSID-(REAL(XLAM)-FREQ)/DZI                                   COSAL
      IF (NUMB.NE.0) GO TO 36                                           COSAL
C     ****** LIMIT ANGLE EXCURSIONS                                     COSAL
      IF (PSID.LT..7*PSID1) PSID=.7*PSID1                               COSAL
      IF (PSID.GT.1.3*PSID1) PSID=1.3*PSID1                             COSAL
   36 CONTINUE                                                          COSAL
C     ***** INCREMENT COUNTER; RESET FOR NEXT ITERATION                 COSAL
      NUMB=NUMB+1                                                       COSAL
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      A1=ALPHA
      B1=BETA
      PSID1=PSID
      ALPHA=WWV*COS(PSID)
      BETA=WWV*SIN(PSID)
C     ***** REFINE LOCAL METHOD GUESS
      XLAM=XLAM+VA*(ALPHA-A1)+VB*(BETA-B1)
      IF (JPASS.NE.0) GO TO 33
      GO TO 32
37    CONTINUE
C     ***** RECOMPUTE PSI AND SAVE
      PSI(1)=PSID-PHI
      PSISAV=PSI(1)
      XLENSAV=XLEN(1)
      NXLEN=1
      NPSI=1
38    CONTINUE
C     ***** RESETS
      ALPHA2=ALPHA
      BETA2=BETA
      XLAM2=XLAM
      VA2=VA
      VB2=VB
C     ***** BRANCH TO INITIAL STATION N-FACTOR COMPUTATION.
      GO TO 50
39    CONTINUE
      IF (NR.NE.1) GO TO 40
C     ***** NR = 1 SETUPS
      XN=XMIN
      DSTZ=DSTZIN
      REY=REYIN
      RADIUS=RADIN
40    CONTINUE
C     ------MAKE CHEBYSHEV COEFFICIENTS
      CALL MAKXLG
41    CONTINUE
C     ***** ITRIV = 1 CODE; INITIAL STATION PORTION
C     ------MAKE NONDIMENSIONAL FREQUENCY
      FREQ=XMFRQ(RFREQ,UE(NZ),DSTZ)
C     ***** IBEGIN = 1 OPTION
      IF (IBEGIN.EQ.0) GO TO 43
      IF (ITRIP.EQ.1.AND.ICON.NE.0) WAVE=WAVSAV
      ITRIP=0
      PHI=ATAN(W(KPTS)/U(KPTS))
      IF (IPSI.EQ.1.AND.ICOUNT.EQ.0) GO TO 42
      IF (ITYP.EQ.0) CALL CRIT (PSICRIT)
      IF (ITYP.EQ.0) PSI(1)=PSICRIT-PHI
      IF (ITYP.EQ.1) PSI(1)=0.0
```

```
42    CONTINUE
      ALPHA=WAVE*COS(PSI(1)+PHI)
      BETA=WAVE*SIN(PSI(1)+PHI)
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA,BETA,XLAM,CSP)
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)
      WRITE (6,130) ALPHA,BETA,XLAM
      IF (AIMAG(XLAM).LT.0.0) WRITE (6,136) WAVE,XC(NZ),NZ
      IF (AIMAG(XLAM).LT.0.0) GO TO 10
43    CONTINUE
C     ****** FIND INITIAL TWO POINTS ON FREQ CURVE FOR ITRIV = 1
      JPASS=0
      IF (IBLIND.EQ.1) JPASS=1
      CALL STARTUP (ALPHA,BETA,PEY,NC,EIGA,A,B,AA,BB,CC,AC,WORKC,
     1 NDIM,M,MG,NG,UU,UWRK,VV,VWRK,CSP,WORK,IR,IC,FREQ,XLAM,VA,VB,
     2 XLAM1,VA1,VB1,EPS,ALPHA1,BETA1,ALPHA2,BETA2)
      IF (AIMAG(XLAM).LT.0.0.OR.AIMAG(XLAM1).LT.0.0)GO TO 44
      GO TO 45
44    CONTINUE
      IF (IBEGIN.EQ.0) GO TO 11
C     ***** LOOP BACK AND READ NEXT STATION IF NO GOOD MODES FOUND
      GO TO 10
45    CONTINUE
C     -------RESETS
      ALPHA1=ALPHA
      BETA1=BETA
      VA1=VA
      VB1=VB
      XLAM1=XLAM
      NUMB=0
C     ***** COMPUTE ESTIMATE FOR XLAM2
      XLAM2=XLAM1+VA1*(ALPHA2-ALPHA1)+VB1*(BETA2-BETA1)
      GO TO 47
46    CONTINUE
      NUMB=NUMB+1
C     -----INITIAL STATION OPTIMIZER LOOP
      WRITE (6,148)
      WRITE (6,122)
C     ***** OPTIMAL CALL TO MAXIMIZE AMPLIFICATION RATE FOR
C     ***** FIXED FREQUENCY
      CALL OPTIMAL (FREQ,ALPHA1,BETA1,XLAM1,VA1,VB1,ALPHA2,BETA2,XLAM2,V
     1A2,VB2,ALPH3,BET3)
      WRITE (6,127) ALPHA1,BETA1,XLAM1,VA1,VB1
      WRITE (6,127) ALPHA2,BETA2,XLAM2,VA2,VB2
C     ***** RESETS
      ALPHA1=ALPHA2
      BETA1=BETA2
```

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      ALPHA2=ALPH3
      BETA2=BET3
      XLAM1=XLAM2
      VA1=VA2
      VB1=VB2
C     ***** REFINE LOCAL METHOD GUESS
      XLAM2=XLAM2+VA2*(ALPHA2-ALPHA1)+VB2*(BETA2-BETA1)
47    CONTINUE
      IF (IGLOB.EQ.2.OR.IGLOB.EQ.3) JPASS=0
      IF (JPASS.NE.0) GO TO 48
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA2,BETA2,XLAM2,CSP)
 48   CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA2,BETA2,XLAM2,VA2,VB2,CSP,WORK)
C     --------TESTS
      IF (NUMB.EQ.0) GO TO 46
      IF (ABS((FREQ-REAL(XLAM2))/FREQ).LE.FROTOL.AND.ABS(G2).LT.2.E-5) G
     1O TO 49
      IF (NUMB.GT.7) WRITE (6,137)
      IF (NUMB.GT.7) GO TO 49
      GO TO 46
49    CONTINUE
      WRITE (6,148)
      WRITE (6,123) NZ,XC(NZ)
50    CONTINUE
      IF (ITRIV.EQ.4.OR.ITRIV.EQ.5.OR.ITRIV.EQ.6) WRITE (6,151) NZ,XC(NZ
     1)
      WRITE (6,127) ALPHA2,BETA2,XLAM2,VA2,VB2
C     ***** EXIT IF INITIAL STATION OPTIMIZER CAME UP WITH A
C     ****** STABLE MODE THREE TIMES IN A ROW
      IF (AIMAG(XLAM2).GT.0.0) GO TO 51
      NPOS=NPOS+1
      IF (NPOS.LT.3) WRITE (6,113)
      IF (NPOS.EQ.3) WRITE (6,135)
      IF (NPOS.EQ.3) CALL EXIT
      IF (IBEGIN.EQ.0) GO TO 11
      GO TO 10
51    CONTINUE
      NPOS=0
      IF (NSTAT.EQ.0) CALL EXIT
      IF (NINTEG.EQ.0) GO TO 57
      IF (NINTEG.NE.1) GO TO 52
C     ***** INITIAL STATION N FACTOR COMPUTATION
      ARG1=0.0
      ARG2=AIMAG(XLAM2)/SQRT((REAL(VA2))**2+(REAL(VB2))**2)/DSTZ
      XN=0.0
      DS=RADIUS*THETA(NZ)
      XN=XN+(ARG1+ARG2)/2.*DS
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52    CONTINUE                                                     COSAL
      IF (NINTEG.EQ.2.AND.NR.EQ.0) GO TO 53                        COSAL
      IF (NINTEG.EQ.2.AND.NR.EQ.2) GO TO 53                        COSAL
      GO TO 54                                                     COSAL
53    CONTINUE                                                     COSAL
      IF (NR.EQ.2) NZERO=NZ-1                                      COSAL
      XN=0.0                                                       COSAL
      ARG1=0.0                                                     COSAL
      ARG2=AIMAG(XLAM2)/SQRT((REAL(VA2))**2+(REAL(VB2))**2)/DSTZ   COSAL
      IF (NZERO.EQ.2) THETA(NZERO)=0.0                             COSAL
      DS=RADIUS*(THETA(NZ)-THETA(NZERO))                           COSAL
      IF (ICOUNT.NE.0) DS=R2*(THETA(NZ)-THETA(NZ-1))               COSAL
      XN=XN+(ARG1+ARG2)/2.*DS                                      COSAL
      GO TO 55                                                     COSAL
54    CONTINUE                                                     COSAL
      XN=XNIN                                                      COSAL
      ARG2=AIMAG(XLAM2)/SQRT((REAL(VA2))**2+(REAL(VB2))**2)/DSTZ   COSAL
      NR=2                                                         COSAL
55    CONTINUE                                                     COSAL
C     ***** INITIAL STATION RESULTS PRINT                          COSAL
      WRITE (6,115) ARG2                                           COSAL
      IF (ITRIV.EQ.4) RFREQ=REAL(XLAM2)*UE(NZ)/2./3.14159/DSTZ     COSAL
      IF (ITRIV.NE.1) GO TO 56                                     COSAL
      PHI=ATAN(W(KPTS)/U(KPTS))                                    COSAL
      XLEN(1)=2.*3.14159*DSTZ/SQRT(ALPHA2**2+BETA2**2)             COSAL
      IF(ALPHA2.LT.0..AND.BETA2.GT.0.) NFAC=1                      COSAL
      IF(ALPHA2.LT.0..AND.BETA2.LT.0.) NFAC=1                      COSAL
      IF(ALPHA2.GT.0..AND.BETA2.GT.0.) NFAC=0                      COSAL
      IF(ALPHA2.GT.0..AND.BETA2.LT.0.) NFAC=2                      COSAL
      PSI(1)=ATAN(BETA2/ALPHA2)-PHI+3.141596*(1-ITYP)*NFAC         COSAL
56    WRITE (6,114) XLEN(1)/CHORD,PSI(1)*57.29577,PHI*57.29577,RFREQ COSAL
      WRITE (6,143)                                                COSAL
      WRITE (6,144) NZ,XN                                          COSAL
      WRITE (6,143)                                                COSAL
C     *******                                                      COSAL
C     ***** NEXT STATION EIGENVALUE ESTIMATOR (FOR ITRIV = 1)      COSAL
C     ******                                                       COSAL
57    CONTINUE                                                     COSAL
      IF (ICOUNT.NE.0) GO TO 58                                    COSAL
      R2=RADIUS                                                    COSAL
C     ***** START MAIN COMPUTATION LOOP                            COSAL
58    CONTINUE                                                     COSAL
C     ***** CHECK SOLUTION ACCURACY AND INCREASE NUMBER OF NODE POINTS COSAL
C     ***** IF NECESSARY                                           COSAL
      IF(ICHEB.EQ.2)GO TO 59                                       COSAL
      NPR=NC+2*IPRZ                                                COSAL
      IF(NPR.EQ.101.AND.NG.EQ.41)GO TO 59                          COSAL
      AIXL=AIMAG(XLAM2)                                            COSAL
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      CXL1=.001
      IF(AIXL.GT.CXL1)GO TO 59
      CXL2=.0005
      CXL3=.0003
      CXL4=.0001
      WRITE(6,139)
      IF(AIXL.LE.CXL1.AND.AIXL.GT.CXL2)NADD=5
      IF(AIXL.LE.CXL2.AND.AIXL.GT.CXL3)NADD=10
      IF(AIXL.LE.CXL3.AND.AIXL.GT.CXL4)NADD=15
      IF(AIXL.LT.CXL4)NADD=20
      NC=NC+2*NADD
      NPP=NC+2*IPRZ
      IF(NPP.GT.101)NC=101-2*IPRZ
      NG=NG+NADD
      IF(NG.GT.41)NG=41
      IF(NG.GT.33)MG=4
      IF (NPP.GE.101) WRITE (6,138)
      IF(NG.EQ.41)WRITE(6,138)
      JPASS=0
 59   CONTINUE
      IF (ITRIV.EQ.4.OR.ITRIV.EQ.5.OR.ITRIV.EQ.6) GO TO 61
C     ***** FOR ITRIV = 1,SAVE PROFILES AT CURRENT STATION
      KSAV=KPTS
      DO 60 J=1,KPTS
      XS(J)=Y(J)
      US(J)=U(J)
      US1(J)=U1(J)
      US2(J)=U2(J)
      WS(J)=W(J)
      WS1(J)=W1(J)
      WS2(J)=W2(J)
      TS(J)=T(J)
      TS1(J)=T1(J)
 60   TS2(J)=T2(J)
 61   CONTINUE
      RSAV=R2
      REY1=REY
      XMCH1=MACH
C     ----READ NEXT STATION
      ARG1=ARG2
      CALL FLOW(NSTART,NZ)
      REYTEMP=REY
      DSTZTMP=DSTZ
      XMTEMP=XMACH
C     ----DETERMINE INTEGRATION PATH AND SCALE REYNOLDS NUMBER AND
C     ----DISPLACEMENT THICKNESS
      IF (NINTEG.EQ.0) GO TO 62
      WRITE (6,147) NZ,RSAV,REYTEMP,DSTZTMP,MACH
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      THH=THETA(NZ)-THETA(NZ-1)
      CALL MAKAPK (VA2,VB2,RSAV,THH,R2,DR,DS)
      CALL RATIO (RADIUS,REYTEMP,DSTZTMP,R2,REY,DSTZ)
      WRITE (6,146) NZ,R2,REY,DSTZ
      WRITE (6,145) DR,DS
      IF (ITRIV.NE.4) GO TO 62
      PHI=ATAN(V(KPTS)/U(KPTS))
      ALPHA2=2.*3.14159*DSTZ/XLEN(1)*COS(PSI(1)+PHI)
      BETA2=2.*3.14159*DSTZ/XLEN(1)*SIN(PSI(1)+PHI)
62    CONTINUE
      IF (ITRIV.EQ.4.OR.ITRIV.EQ.5.OR.ITRIV.EQ.6) GO TO 66
C     ----INTERPOLATE NEW PROFILE ONTO GRID OF OLD PROFILE
C     ----CREATE 10 PERCENT DISPLACED PROFILE
      IF(Y(KPTS).LE.XS(KSAV))Y(KPTS)=1.00001*XS(KSAV)

      CALL BSLINT(0,3,Y,U,KPTS,XS,UM,KSAV)
      CALL BSLINT(0,3,Y,U1,KPTS,XS,UM1,KSAV)
      CALL BSLINT(0,3,Y,U2,KPTS,XS,UM2,KSAV)
      CALL BSLINT(0,3,Y,W,KPTS,XS,WM,KSAV)
      CALL BSLINT(0,3,Y,W1,KPTS,XS,WM1,KSAV)
      CALL BSLINT(0,3,Y,W2,KPTS,XS,WM2,KSAV)
      CALL BSLINT(0,3,Y,T,KPTS,XS,TM,KSAV)
      CALL BSLINT(0,3,Y,T1,KPTS,XS,TM1,KSAV)
      CALL BSLINT(0,3,Y,T2,KPTS,XS,TM2,KSAV)
      DO 211 I=1,KSAV
      UM(I)=US(I)+.1*(UM(I)-US(I))
      UM1(I)=US1(I)+.1*(UM1(I)-US1(I))
      UM2(I)=US2(I)+.1*(UM2(I)-US2(I))
      WM(I)=WS(I)+.1*(WM(I)-WS(I))
      WM1(I)=WS1(I)+.1*(WM1(I)-WS1(I))
      WM2(I)=WS2(I)+.1*(WM2(I)-WS2(I))
      TM(I)=TS(I)+.1*(TM(I)-TS(I))
      TM1(I)=TS1(I)+.1*(TM1(I)-TS1(I))
      TM2(I)=TS2(I)+.1*(TM2(I)-TS2(I))
211     CONTINUE
      KTEMP=KPTS
      DO 212 I=1,KPTS
      XM(I)=Y(I)
      US(I)=U(I)
      US1(I)=U1(I)
      US2(I)=U2(I)
      WS(I)=W(I)
      WS1(I)=W1(I)
      WS2(I)=W2(I)
      TS(I)=T(I)
      TS1(I)=T1(I)
      TS2(I)=T2(I)
212     CONTINUE
```

```
      KPTS=KSAV
      DO 213 I=1,KSAV
      Y(I)=XS(I)
      U(I)=UM(I)
      U1(I)=UM1(I)
      U2(I)=UM2(I)
      W(I)=WM(I)
      W1(I)=WM1(I)
      W2(I)=WM2(I)
      T(I)=TM(I)
      T1(I)=TM1(I)
      T2(I)=TM2(I)
  213    CONTINUE
C     -----MAKE REY2
      REY2=REY1+.1*(REY-REY1)
      XMACH=XMCH1+.1*(MACH-XMCH1)
      XMACH=XMACH*XMACH
      RTEMP=REY
      REY=REY2
C     ----MAKE CHEBYSHEV COEFFICIENTS
      CALL MAKXLG
      XLAMA=XLAM2
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA2,BETA2,XLAM2,VA2,VB2,CSP,WORK)
      REY=RTEMP
      XMACH=XMTEMP
C     -----MAKE DERIVATIVES
      DWDS=(XLAM2-XLAMA)/(XC(NZ)-XC(NZ-1))*10.
      XGAM=-REAL(DWDS)*(XC(NZ)-XC(NZ-1))/((REAL(VA2))**2+(REAL(VB2))**2)
      AAO=XGAM*REAL(VA2)
      BBO=XGAM*REAL(VB2)
      ALPHA2=ALPHA2+AAO
      BETA2=BETA2+BBO
C     ***** EXTRAPOLATE EIGENVALUE FOR NEW STATION LOCAL METHOD(ITRIV=1)
      XLAM2=XLAMA+DWDS*(XC(NZ)-XC(NZ-1))+VA2*AAO+VB2*BBO
        KPTS=KTEMP
      DO 214 I=1,KPTS
      Y(I)=XM(I)
      U(I)=US(I)
      U1(I)=US1(I)
      U2(I)=US2(I)
      W(I)=WS(I)
      W1(I)=WS1(I)
      W2(I)=WS2(I)
      T(I)=TS(I)
      T1(I)=TS1(I)
  214   T2(I)=TS2(I)
   66 CONTINUE
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      CALL MAKXLG
C     ----MAKE NON-DIMENSIONAL FREQUENCY
      IF (ITRIV.EQ.4) GO TO 67
      FREQ=XMFRQ(RFREQ,UE(NZ),DSTZ)
67    CONTINUE
      IF (ITRIV.NE.5.AND.ITRIV.NE.6) GO TO 74
C     ***** MAKE NEW STATION WAVE NUMBERS AND ANGLES
      NUMB=0
      WWV=2.*3.14159*DSTZ/XLEN(1)
      PHI=ATAN(W(KPTS)/U(KPTS))
      IF (ITRIV.NE.5) GO TO 74
      IF (ITYP.NE.0) GO TO 68
      CALL CRIT (PSICRIT)
      PSI(1)=PSICRIT-PHI
68    CONTINUE
      PSID=PSI(1)+PHI
      IF (IPR7.EQ.0) GO TO 69
      WRITE (6,116) XLEN(1)/CHORD,PSI(1)*57.29577,PHI*57.29577,PSID*57.2
     19577
69    CONTINUE
      JPASS=0
C     ***** ITRIV = 5 LOOP
70    CONTINUE
      A1=ALPHA2
      B1=BETA2
      ALPHA2=WWV*COS(PSID)
      BETA2=WWV*SIN(PSID)
C     ***** REFINE LOCAL METHOD GUESS
      IF (NUMB.NE.0) XLAM2=XLAM2+VA2*(ALPHA2-A1)+VB2*(BETA2-B1)
      IF (JPASS.NE.0) GO TO 71
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA2,BETA2,XLAM2,CSP)
71    CONTINUE
      CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA2,BETA2,XLAM2,VA2,VB2,CSP,WORK)
      IF (IPR7.EQ.0) GO TO 72
      WRITE (6,111) NUMB,PSID*57.29577
      WRITE (6,127) ALPHA2,BETA2,XLAM2,VA2,VB2
72    CONTINUE
C     ***** TESTS
      IF (ABS((FREQ-REAL(XLAM2))/FREQ).LE.FROTOL) GO TO 73
      IF (NUMB.GT.7) GO TO 73
      IF (AIMAG(XLAM2).LT.0.0.AND.NUMB.GT.3) GO TO 73
C     ***** UPDATE LOCAL WAVE ANGLE
      DZI=WWV*(COS(PSID)*REAL(VB2)-SIN(PSID)*REAL(VA2))
      PSID=PSID-(REAL(XLAM2)-FREQ)/DZI
      NUMB=NUMB+1
      GO TO 70
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C      ***** LOOP BACK FOR NEXT ITERATION
73     CONTINUE
C      ***** MAKE NEW WAVE ANGLE WITH RESPECT TO LOCAL FREE STREAM
       PSI(1)=PSID-PHI
74     CONTINUE
       IF (ITRIV.NE.6) GO TO 79
       JPASS=0
75     CONTINUE
C      ***** ITRIV = 6 LOOP
       A1=ALPHA2
       B1=BETA2
       ALPHA2=WWV*COS(PSI(1)+PHI)
       BETA2=WWV*SIN(PSI(1)+PHI)
C      ***** REFINE LOCAL METHOD GUESS
       IF (NUMB.NE.0) XLAM2=XLAM2+VA2*(ALPHA2-A1)+VB2*(BETA2-B1)
       IF (JPASS.NE.0) GO TO 76
       CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
      1 ALPHA2,BETA2,XLAM2,CSP)
76     CONTINUE
       CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
      1 ALPHA2,BETA2,XLAM2,VA2,VB2,CSP,WORK)
       IF (IPP7.EQ.0) GO TO 77
       WRITE (6,117) NUMB,WWV
       WRITE (6,127) ALPHA2,BETA2,XLAM2,VA2,VB2
77     CONTINUE
C      ***** TESTS
       IF (ABS((FREQ-REAL(XLAM2))/FREQ).LE.FRQTOL) GO TO 78
       IF (NUMB.GT.7) GO TO 78
       IF (AIMAG(XLAM2).LT.0.0.AND.NUMB.GT.4) GO TO 78
C      ***** UPDATE WAVENUMBER
       DLAM=REAL(VA2)*COS(PSI(1)+PHI)+REAL(VB2)*SIN(PSI(1)+PHI)
       WWV=WWV-(REAL(XLAM2)-FREQ)/DLAM
       NUMB=NUMB+1
       GO TO 75
C      ***** COMPUTE NEW PHYSICAL WAVELENGTH AT CURRENT STATION
78     XLEN(1)=2.*3.14159*DSTZ/WWV
79     CONTINUE
       IF (ITRIV.EQ.5.OR.ITRIV.EQ.6) GO TO 97
C      ***** ITRIV = 1: GENERATE TWO POINTS CLOSE TO FREQ CURVE TO START
C      ***** NEW STATION OPTIMIZER
C      ----FIRST POINT
       IGESS=0
80     IF (IGLOB.EQ.2) JPASS=0
       IF (JPASS.NE.0) GO TO 81
       CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
      1 ALPHA2,BETA2,XLAM2,CSP)
       JPASS=0
81     CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
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     1 ALPHA2,BETA2,XLAM2,VA2,VB2,CSP,WORK)
      IF (ITRIV.EQ.4) GO TO 97
      IGESS=IGESS+1
      IF (IPR7.EQ.0) GO TO 82
      WRITE (6,124) IGESS,XLAM2
 82   CONTINUE
C     ***** ITOP SET TO ONE IN DATA STATEMENT--IF USER NEEDS MORE
C     ****** ITERATIONS,DATA STATEMENT CHANGE IS NECESSARY
      IF (IGESS.EQ.ITOP) GO TO 83
      IF (ABS((FREQ-REAL(XLAM2))/FREQ).LE.FROTOL) GO TO 83
      RVA=REAL(VA2)
      RVB=REAL(VB2)
      AVA=AIMAG(VA2)
      AVB=AIMAG(VB2)
      SPD=RVA**2+RVB**2
      ALPHA2=ALPHA2+RVA*(FREQ-REAL(XLAM2))/SPD
      BETA2=BETA2+RVB*(FREQ-REAL(XLAM2))/SPD
      GO TO 80
 83   CONTINUE
C     ---SECOND POINT
      WAVE=ALPHA2**2+BETA2**2
      RVA=REAL(VA2)
      RVB=REAL(VB2)
      IF (ABS(RVA).GT.ABS(RVB)) GO TO 84
      S=.05*SQRT(WAVE)/RVB
      GO TO 85
 84   S=.05*SQRT(WAVE)/RVA
 85   ALPHA1=ALPHA2-S*RVB
      BETA1=BETA2+S*RVA
      JGESS=0
      XLAM1=XLAM2
 86   IF (IGLOB.EQ.2) JPASS=0
      IF (JPASS.NE.0) GO TO 87
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA1,BETA1,XLAM1,CSP)
 87   CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA1,BETA1,XLAM1,VA1,VB1,CSP,WORK)
      JGESS=JGESS+1
      IF (IPR7.EQ.0) GO TO 88
      WRITE (6,125) JGESS,XLAM1
 88   CONTINUE
C     ***** JTOP SET TO ONE IN DATA STATEMENT.--IF USER NEEDS MORE
C     ***** ITERATIONS, DATA STATEMENT CHANGE IS NECESSARY
      IF (JGESS.EQ.JTOP) GO TO 89
      IF (ABS((FREQ-REAL(XLAM1))/FREQ).LE.FROTOL) GO TO 89
      RVA=REAL(VA1)
      RVB=REAL(VB1)
      AVA=AIMAG(VA1)
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      AVB=AIMAG(VB1)                                                    COSAL  1057
      SPD=PVA**2+PVB**2                                                 COSAL  1058
      ALPHA1=ALPHA1+RVA*(FREQ-REAL(XLAM1))/SPD                          COSAL  1059
      BETA1=BETA1+RVB*(FREQ-REAL(XLAM1))/SPD                            COSAL  1060
      GO TO 86                                                          COSAL  1061
   89 CONTINUE                                                          COSAL  1062
      NUMB=0                                                            COSAL  1063
C     CCCCCCCC---OPTIMIZER LOOP-------                                  COSAL  1064
C     ***** ITRIV = 1  MAXIMIZE AMPLIFICATION FOR FIXED PHYSICAL        COSAL  1065
C     ***** FREQUENCY                                                   COSAL  1066
   90 CONTINUE                                                          COSAL  1067
      NUMB=NUMB+1                                                       COSAL  1068
      WRITE (6,148)                                                     COSAL  1069
      WRITE (6,126) NUMB                                                COSAL  1070
      ISHIFT=0                                                          COSAL  1071
   91 CONTINUE                                                          COSAL  1072
      CALL OPTIMAL (FREQ,ALPHA1,BETA1,XLAM1,VA1,VB1,ALPHA2,BETA2,XLAM2,VCOSAL  1073
     1A2,VB2,ALPH3,BET3)                                                COSAL  1074
C     -----TEST VECTOR DIRECTION IN ALPHA--BETA SPACE                   COSAL  1075
      IPOINT=0                                                          COSAL  1076
      IF (ABS(HN/H).GT.0.5) IPOINT=1                                    COSAL  1077
      IF (IPOINT.EQ.0) GO TO 95                                         COSAL  1078
C     ----PERFORM INDEX 1  SHIFT                                        COSAL  1079
      ISHIFT=ISHIFT+1                                                   COSAL  1080
      WRITE (6,121)                                                     COSAL  1081
      IF (ISHIFT.EQ.4) WRITE (6,120)                                    COSAL  1082
      IF (ISHIFT.EQ.4) NUMB=100                                         COSAL  1083
      IF (ISHIFT.EQ.4) GO TO 95                                         COSAL  1084
      WAVE=ALPHA2**2+BETA2**2                                           COSAL  1085
      RVA=REAL(VA2)                                                     COSAL  1086
      RVB=REAL(VB2)                                                     COSAL  1087
      IF (ABS(RVA).GT.ABS(RVB)) GO TO 92                                COSAL  1088
      S=.01*SQRT(WAVE)/RVB                                              COSAL  1089
      GO TO 93                                                          COSAL  1090
   92 S=.01*SQRT(WAVE)/RVA                                              COSAL  1091
   93 ALPHA1=ALPHA2-S*RVB                                               COSAL  1092
      BETA1=BETA2+S*RVA                                                 COSAL  1093
      IF (IGLOB.EQ.2) JPASS=0                                           COSAL  1094
      IF (JPASS.NE.0) GO TO 94                                          COSAL  1095
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,          COSAL  1096
     1 ALPHA1,BETA1,XLAM1,CSP)                                          COSAL  1097
   94 CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,               COSAL  1098
     1 ALPHA1,BETA1,XLAM1,VA1,VB1,CSP,WORK)                             COSAL  1099
      GO TO 91                                                          COSAL  1100
   95 CONTINUE                                                          COSAL  1101
C     ***** RESETS                                                      COSAL  1102
      ALPHA1=ALPHA2                                                     COSAL  1103
      BETA1=BETA2                                                       COSAL  1104
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      ALPHA2=ALPH3
      BETA2=BET3
      XLAM1=XLAM2
      VA1=VA2
      VB1=VB2
      IF (IGLOB.EQ.2) JPASS=0
C     ***** REFINE EIGENVALUE GUESS FOR LOCAL METHOD
      XLAM2=XLAM2+VA2*(ALPHA2-ALPHA1)+VB2*(BETA2-BETA1)
      IF (JPASS.NE.0) GO TO 96
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA2,BETA2,XLAM2,CSP)
   96 CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA2,BETA2,XLAM2,VA2,VB2,CSP,WORK)
   97 CONTINUE
      IF (ITRIV.EQ.4) WRITE (6,152) XLEN(1)/CHORD,PSI(1)*57.29577,NZ,PHI
     1*57.29577,ALPHA2,BETA2,XLAM2
      IF (ITRIV.EQ.4) WRITE (6,132) VA2,VB2
      IF (ITRIV.EQ.6) WRITE (6,118) XLEN(1)/CHORD,PSI(1)*57.29577
      IF (ITRIV.NE.4) WRITE (6,127) ALPHA2,BETA2,XLAM2,VA2,VB2
      IF (ITRIV.EQ.4.OR.ITRIV.EQ.5.OR.ITRIV.EQ.6) GO TO 99
C     ***** ITRIV = 1 TESTS
C     --------TESTS
      IF (NUMB.EQ.1) GO TO 90
      IF (NUMB.GT.7) GO TO 98
      IF (ABS((FREQ-REAL(XLAM2))/FREQ).LE.FROTOL.AND.ABS(G2).LT.2.E-5) G
     1O TO 98
C     ***** LOOP TO NEXT ITERATION
      GO TO 90
   98 CONTINUE
      IF (NUMB.GT.7) WRITE (6,137)
   99 CONTINUE
C     ***** TESTS OF MODE SIGN,ACCURACY ETC.
      IF (AIMAG(XLAM2).LT.0.0)ITRIP=1
      IF (ITRIP.EQ.0) IBEGIN=0
      IF (ITRIP.EQ.1.AND.ICON.NE.0) GO TO 100
      GO TO 101
  100 CONTINUE
      ICOUNT=ICOUNT+1
      IF (ICOUNT.GT.1.AND.ICON.EQ.1) WRITE (6,140)
      IF (ICOUNT.GT.1.AND.ICON.EQ.1) CALL EXIT
      WRITE (6,141) ICON
      IBEGIN=1
C     ***** STABLE REGION ENCOUNTERD; ITRIV = 1 LOOPBACK
      IF (ITRIV.EQ.1) GO TO 10
  101 CONTINUE
C     ***** STABLE REGION ENCOUNTERED. ITRIV = 4;5;6 LOOPBACK
      IF ((ITRIP.EQ.1.AND.ICON.NE.0).AND.(ITRIV.EQ.4.OR.ITRIV.EQ.5.OR.IT
     1RIV.EQ.6)) GO TO 11
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      IF (ITRIV.EQ.1) GO TO 102
C     ***** SAVE LAST UNSTABLE MODE ANGLE AND WAVELENGTH FOR
C     ***** ITRIV = 4;5;6
      PSISAV=PSI(1)
      XLENSAV=XLEN(1)
      NXLEN=1
      NPSI=1
  102 CONTINUE
C     ***** FOR ITRIV = 1, SAVE LAST UNSTABLE WAVENUMBER
      WAVSAV=SQRT(ALPHA2**2+BETA2**2)
      IF (AIMAG(XLAM2).LT.0.)WRITE(6,140)
      IF (AIMAG(XLAM2).LT.0.)CALL EXIT
      IF (NINTEG.EQ.0) GO TO 104
C     ------INTEGRATE N FACTOR
      ARG2=AIMAG(XLAM2)/SQRT((REAL(VA2))**2+(REAL(VB2))**2)/DSTZ
      XN=XN+(ARG1+ARG2)/2.*DS
      WRITE (6,115) ARG2
      IF (ITRIV.EQ.4) RFREQ=REAL(XLAM2)*UE(NZ)/2./3.14159/DSTZ
      IF (ITRIV.NE.1) GO TO 103
      XLEN(1)=2.*3.14159*DSTZ/SQRT(ALPHA2**2+BETA2**2)
      PHI=ATAN(W(KPTS)/U(KPTS))
      IF(ITYP.NE.0) GO TO 501
      IF(ALPHA2.LT.0..AND.BETA2.GT.0.) GO TO 501
      IF(ALPHA2.LT.0..AND.BETA2.LT.0.) GO TO 201
      IF(ALPHA2.GT.0..AND.BETA2.GT.0.) GO TO 301
      IF(ALPHA2.GT.0..AND.BETA2.LT.0.) GO TO 401
  201 PSI(1)=ATAN(BETA2/ALPHA2)-PHI+3.14159
      GO TO 103
  301 PSI(1)=ATAN(BETA2/ALPHA2)-PHI
      GO TO 103
  401 PSI(1)=ATAN(BETA2/ALPHA2)-PHI+2.*3.14159
      GO TO 103
  501 PSI(1)=ATAN(BETA2/ALPHA2)-PHI+3.14159*(1-ITYP)
  103 WRITE (6,114) XLEN(1)/CHORD,PSI(1)*57.29577,PHI*57.29577,RFREQ
      WRITE (6,143)
      WRITE (6,142) NZ,XC(NZ),XN
      WRITE (6,143)
  104 CONTINUE
      IF (NZ.EQ.NSTOP) CALL EXIT
C     ***** NORMAL MAIN LOOP TERMINATOR
      GO TO 58
C     *****************************************************************
C                               FORMATS
C     *****************************************************************
C
C
  105 FORMAT (5X,8HXLENC = ,E15.8,5X,6HPSI = ,2X,F10.6,2X,7HDEGREES)
  106 FORMAT (2X,28HITRIV = 5 OPTION AT STATION ,2X,I5,2X,41HLOOKING FOR
     )
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     1    UNSTABLE MODE FOR XLENC = ,2X,E15.8/2X,6HPSI = ,2X,F10.6,2X,16COSAL
     2HDEGREES,,, PHI= ,2X,F10.6)                                         COSAL
107   FORMAT (/1X,6HITRIV=,2X,I5,2X,10HAT STATION,I5,2X,35HLOOKING FOR UCOSAL
     1NSTABL MODE AT PSI =  ,F10.6,2X,10H  DEGREES /2X,9HXLENC =   ,E15.8COSAL
     2)                                                                   COSAL
108   FORMAT (2X,6HITRIV=,2X,I5,2X,59HNO INSTABILITY  FOR INPUT     WAVECOSAL
     1LENGTH RANGE AT STATION  ,I5)                                       COSAL
109   FORMAT (1X,12HITERATION # ,2X,I5,2X,15HINITIAL XLENC= ,2X,E15.8,2XCOSAL
     1,6HPSI = ,F10.6)                                                    COSAL
110   FORMAT (10X,6HITRIV=,2X,I5,2X,47H---NO GOOD UNSTABLE MODE AT A    COSAL
     1  FREQUENCY = ,E15.8,3X,8H  C.P.S./10X,10HAT STATION,2X,I5,2X,18HGCOSAL
     2O TO NEXT STATION)                                                  COSAL
111   FORMAT (10X,25HITRIV = 5, ITERATION # = ,I3,10X,7HPSID = ,5X,F10.6COSAL
     1)                                                                   COSAL
112   FORMAT (10X,67HITRIV = 5  OPTION FAILED TO FIND GOOD UNSTABLE MODECOSAL
     1 OF FREQUENCY = ,E15.8,3X,8H  C.P.S./10X,10HAT STATION,2X,I5,2X,18COSAL
     2HGO TO NEXT STATION)                                                COSAL
113   FORMAT (///10X,108HINITIAL STATION OPTIMIZER CAME UP WITH A BAD    COSAL
     1 MODE.  WILL TRY AGAIN AT NEXT STATION.  POSSIBLILITY IS THAT/10X,COSAL
     294HINSTABILITY CORRESPONDING TO XLENC IS TOO FAR FROM THE REAL   MCOSAL
     3AXIMUM. OPTIMIZER CANNOT DIGEST/10X,18HTRY CHANGING XLENC///)      COSAL
114   FORMAT (10X,8HXLENC = ,E15.8,5X,5HPSI= ,F10.6,5X,5HPHI= ,5X,F10.6,COSAL
     15X,8HFREQ = ,2X,E15.8,2X,2HHZ)                                      COSAL
115   FORMAT (20X,7HARG =  ,E15.8)                                        COSAL
116   FORMAT (10X,13HWAVELENGTH = ,E15.8,5X,6HPSI = ,F10.6,5X,6HPHI = ,FCOSAL
     110.6,5X,7HPSID = ,F10.6)                                            COSAL
117   FORMAT (2X,23H ITRIV = 6 ITERATION # ,I5,10H   WWV =  ,2X,E15.8)  COSAL
118   FORMAT (2X,12HNEW XLENC = ,2X,E15.8,2X,6HPSI = ,2X,F10.6,2X,5H DEGCOSAL
     1.)                                                                  COSAL
120   FORMAT (1X,25HEXCEED 3 INDEX  1  SHIFTS)                            COSAL
121   FORMAT (/1X,22H----INDEX 1  SHIFT----)                              COSAL
122   FORMAT (/1X,30HINITIAL STATION OPTIMIZER LOOP/)                     COSAL
123   FORMAT (/1X,44HEND OF INITIAL STATION OPTIMIZER AT STATION ,3X,I5,COSAL
     13X,7HX/C =  ,F10.6,3X,17HFINAL RESULTS ARE)                         COSAL
124   FORMAT (1X,26HFIRST PT ESTIMATOR, IGESS=,I5,10X,6HOMEGA=,2E20.13) COSAL
125   FORMAT (1X,27HSECOND PT ESTIMATOR, JGESS=,I5,10X,6HOMEGA=,2E20.13)COSAL
126   FORMAT (1X,26HMAIN OPTIMIZER LOOP, NUMB=,I5)                        COSAL
127   FORMAT (/3X,6HALPHA=,3X,F12.8,3X,5HBETA=,3X,F12.8,10X,6HOMEGA=,5X,COSAL
     12E20.13//5X,23HGROUP VELOCITY COMPUTED/10X,4HVA =,2E20.13,5X,4HVB COSAL
     2=,2E20.13)                                                          COSAL
128   FORMAT (/10X,47HSIMPLE EIGENVALUE COMPUTATION AT STATION NUMBER,3XCOSAL
     1,I3,5X,8H X/C =  ,3X,F10.6,5X,I5,3X,16HNODE POINTS USED,/,         COSAL
     2 1X,*REY = *,F10.4,5X,*MACH NO. = *,F6.3)                           COSAL
129   FORMAT (1H1)                                                        COSAL
130   FORMAT (/,3X,6HALPHA=,3X,F12.8,3X,5HBETA=,3X,F12.8,10X,7HOMEGA =,5COSAL
     1X,2E20.13)                                                          COSAL
131   FORMAT (//,5X,23HGROUP VELOCITY COMPUTED/)                          COSAL
132   FORMAT (10X,5HVA  =,2E20.13,5X,5HVB = ,2E20.13)                     COSAL
```

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133   FORMAT (20A4)                                                    COSAL
135   FORMAT (//10X,67HINITIAL STATION OPTIMIZER ENDED WITH A STABLE MODCOSAL
     1E. RUN WILL ABORT.)                                              COSAL
136   FORMAT (/1X,82HIBEGIN =1 FAILED TO FIND ACCURATE UNSTABLE        COSAL
     1     MODE OF WAVE NUMBER WAVE=  ,F10.6,2X,8H X/C =  ,F10.6,10HAT STCOSAL
     2ATION,I5,/1X,26HPROCEEDING TO NEXT STATION/)                     COSAL
137   FORMAT (/1X,86H          OPTIMIZER EXCEEDED REASONABLE NUMBECOSAL
     1R  OF ITERATIONS FOR CONVERGENCE---/,1X,65HCHECK RESULTS,ESPECIALLCOSAL
     2Y   REAL PARTS OF OMEGA AND GROUP VELOCITY/)                     COSAL
138   FORMAT (/1X,54HNC HAS REACHED MAXIMUM ALLOWABLE NUMBER OF POLYNOMICOSAL
     1ALS/)                                                            COSAL
139   FORMAT (/1X,40HNUMBER OF POLYNOMIALS IS BEING INCREASED)          COSAL
140   FORMAT (/1X,52H$$$-STABLE REGION ENCOUNTERED-PROGRAM TERMINATES-$$COSAL
     1$)                                                               COSAL
141   FORMAT (/1X,38H$$$ STABLE REGION ENCOUNTERED--ICON = ,I5,2X,36HWASCOSAL
     1 SELECTED----PROGRAM CONTINUES$$$)                               COSAL
142   FORMAT (1X,19HN FACTOR AT STATION,I5,3X,6HX/C = ,F10.7,3X,6HIS N =COSAL
     1,F7.3)                                                           COSAL
143   FORMAT (1X,54H$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$COSAL
     1$$)                                                              COSAL
144   FORMAT (1X,33H N FACTOR AT INITIAL STATION NO. ,2X,I5,2X,6HIS N= ,COSAL
     1F7.3)                                                            COSAL
145   FORMAT (2X,3HDR=,E15.7,3X,3HDS=,E15.7)                           COSAL
146   FORMAT (1X,10HSTATION NO,I5,3X,10HNEW RADIUS,E15.7,3X,7HNEW REY,E1COSAL
     15.7,3X,8HNEW DSTZ,E15.7)                                         COSAL
147   FORMAT (1X,10HSTATION NO,I5,3X,15HPREVIOUS RADIUS,E15.7,3X,12HORIGCOSAL
     1INAL REY,E15.7,3X,13HORIGINAL DSTZ,E15.7,/,1X,                   COSAL
     2 *LOCAL MACH NO. = *,F6.3)                                       COSAL
148   FORMAT (///)                                                     COSAL
149   FORMAT (///5X,47HFOR ITRIV=4 OPTION, NO UNSTABLE MODE AT STATION,1COSAL
     1X,I3,1X,6HXLENC=,1X,E15.8,1X,4HPSI=,1X,F8.3,1X,7HDEGREES///)     COSAL
150   FORMAT (///5X,47HFOR ITRIV=5 OPTION, NO UNSTABLE MODE AT STATION,1COSAL
     1X,I3,1X,6HXLENC=,1X,E15.8,1X,4HPSI=,1X,F8.3,1X,7HDEGREES///)     COSAL
151   FORMAT (11X,19HINITIAL STATION NO.,3X,I5,3X,4HX/C=,2X,F10.6,3X,11HCOSAL
     1RESULTS ARE/)                                                    COSAL
152   FORMAT (/1X,45HITRIV = 4 OPTION; FOLLOWING FIXED ANGLE WAVE ,2X,8HCOSAL
     1XLENC = ,2X,F15.8,2X,/1X,6HPSI = ,F10.6,1X,19HDEGREES ,AT STATION,COSAL
     2I5/1X,6HPHI = ,2X,F10.6,1X,8HALPHA = ,F10.6,2X,7HBETA = ,F10.6/1X,COSAL
     39HOMEGA =   ,2E20.13/)                                           COSAL
159   FORMAT(2X,*CHORD = *,F6.3,* FT*)                                 COSAL
      END                                                              COSAL
      SUBROUTINE CHECK (TITLE)                                         COSAL
      DIMENSION TITLE(5)                                               COSAL
      WRITE (6,1)                                                      COSAL
      WRITE (6,2)                                                      COSAL
      WRITE (6,3) TITLE                                                COSAL
      WRITE (6,4)                                                      COSAL
      CALL EXIT                                                        COSAL
```

```
      RETURN
C
1     FORMAT (1H1)
2     FORMAT (////////////////////)
3     FORMAT (20X,5A10)
4     FORMAT (///20X,10HRUN ABORTS/20X,72HSEE INSTRUCTIONS AT BEGINNING
     1OF SOURCE LISTING FOR CORRECT INPUT VALUES)
      END
      SUBROUTINE CRIT (PSICRIT)
      COMMON /MFLO/ KPTS,X(102),U0(102),U1(102),U2(102),W0(102),
     1 W1(102),W2(102)
      B1=1.E6
      NMP4=KPTS-4
      DO 1 J=2,NMP4
      IF (U0(J).GT..999) GO TO 2
      A1=U0(J)/W0(J)
      A2=U2(J)/W2(J)
      B2=A1-A2
      IF ((B2.GE.0..AND.B1.LE.0.).OR.(B2.LE.0..AND.B1.GE.0.)) JSAVE=J
      B1=B2
1     CONTINUE
2     CONTINUE
      PSICRIT=-ATAN(U0(JSAVE)/W0(JSAVE))+3.1415977
      RETURN
      END
      SUBROUTINE WING (NZT)
      REAL MUE
      COMMON /WING/ XC(60),THETA(60)
      COMMON /EDGE/ TE,MUE,UE(60)
      DO 4 I=1,NZT
      READ(7)XC(I),THETA(I),UE(I)
4     CONTINUE
      RETURN
      END
      FUNCTION XMFRQ (RFREQ,UE,DSTZ)
      XMFRQ=2.*3.14159*RFREQ*DSTZ/UE
      WRITE (6,1) XMFRQ
      RETURN
C
1     FORMAT (//1X,51HNON-DIMENSIONAL FREQUENCY AT THIS STATION IS FREQ=
     1 ,F20.13)
      END
      SUBROUTINE MAKARK (VA,VB,R1,THET,R2,DR,DS)
      COMPLEX VA,VB
      PSI=ATAN(REAL(VB)/REAL(VA))
      PHI=3.1415926535897/2.-PSI
      GAM=3.1415926535897-THET-PHI
      R2=R1*SIN(PHI)/SIN(GAM)
```

```
      DR=R2-R1                                                          COSAL     1345
      DS=DR**2+R1**2*THET**2                                            COSAL     1346
      DS=SQRT(DS)                                                       COSAL     1347
      RETURN                                                            COSAL     1348
      END                                                               COSAL     1349
      SUBROUTINE RATIO (RADBAS,REYBAS,DSTZBAS,RADNEW,REYNEW,DSTZNEW)    COSAL     1350
      FAC= SQRT(RADNEW/RADBAS)                                          COSAL     1351
      REYNEW=FAC*REYBAS                                                 COSAL     1352
      DSTZNEW=FAC*DSTZBAS                                               COSAL     1353
      RETURN                                                            COSAL     1354
      END                                                               COSAL     1355
      SUBROUTINE MAKXLG                                                 COSAL     1356
      COMMON /MAP/ ETAE                                                 COSAL     1357
      COMMON /GG/ G,XL                                                  COSAL     1358
      COMMON /MFLO/ KPTS,X,UO                                           COSAL     1359
      DIMENSION X(102), UO(102)                                         COSAL     1360
      DO 1 J=1,KPTS                                                     COSAL     1361
      IF(UO(J).LT..5)GO TO 1                                            COSAL     1362
      XL=2.*X(J)                                                        COSAL     1363
      GO TO 2                                                           COSAL     1364
1     CONTINUE                                                          COSAL     1365
2     CONTINUE                                                          COSAL     1366
      G=XL/ETAE+1.                                                      COSAL     1367
      RETURN                                                            COSAL     1368
      END                                                               COSAL     1369
      SUBROUTINE MAXEIG (EIG,XLAM,N,M,INDEX)                            COSAL     1370
      COMPLEX EIG(1),XLAM                                               COSAL     1371
      DIMENSION INDEX(1)                                                COSAL     1372
      XLAM=EIG(1)                                                       COSAL     1373
      NNN=N                                                             COSAL     1374
      DO 1 I=2,NNN                                                      COSAL     1375
1     IF (AIMAG(XLAM).LT.AIMAG(EIG(I))) XLAM=EIG(I)                     COSAL     1376
      M=0                                                               COSAL     1377
      DO 2 I=1,NNN                                                      COSAL     1378
      IF (AIMAG(EIG(I)).GT.0.0) M=M+1                                   COSAL     1379
      IF (AIMAG(EIG(I)).GT.0.0) INDEX(M)=I                              COSAL     1380
2     CONTINUE                                                          COSAL     1381
C     INDEX(I)   (I=1 TO M) GIVES LOCATIONS OF POSITIVE MODES           COSAL     1382
C     M IS NUMBER OF POSITIVE MODES                                     COSAL     1383
C      XLAM IS LARGEST MODE (POSITIVE OR NEGATIVE)                      COSAL     1384
      IF(M.EQ.1)RETURN                                                  COSAL     1385
      IF(M.EQ.0)GO TO 10                                                COSAL     1386
      WRITE(6,3)M                                                       COSAL     1387
 3    FORMAT(///,5X,I5,* UNSTABLE MODES FOUND IN GLOBAL CALCULATION. THECOSAL     1388
     1 MOST UNSTABLE OF THESE WILL BE*,/,9X,*FOLLOWED IN SUBSEQUENT LOCACOSAL     1389
     2L CALCULATION. THE UNSTABLE MODES FOUND ARE :*,/)                 COSAL     1390
      WRITE(6,4)(EIG(INDEX(J)),J=1,M)                                   COSAL     1391
 4    FORMAT(10X,2G20.13,/)                                             COSAL     1392
```

```
      RETURN                                                            COSAL    1393
   10 WRITE(6,11)                                                       COSAL    1394
   11 FORMAT(///,9X,*NO UNSTABLE MODE FOUND IN GLOBAL CALCULATION. THE LCOSAL    1395
     1EAST STABLE MODE WILL BE*,/,9X,*USED IN SUBSEQUENT LOCAL EIGENVALUCOSAL    1396
     2E SEARCH. THIS IS :*,/)                                           COSAL    1397
      N6=NNN-6                                                          COSAL    1398
      I5=5                                                              COSAL    1399
      XLAM=EIG(I5)                                                      COSAL    1400
      RFAC=1./(REAL(EIG(NNN-5)))                                        COSAL    1401
      DO 15 I=6,N6                                                      COSAL    1402
      PRR=REAL(EIG(I))*RFAC                                             COSAL    1403
      IF(PRR.GT..8)GO TO 15                                             COSAL    1404
      IF(PRR.LT.0..AND.ABS(PRR).GT..001)GO TO 15                        COSAL    1405
      IF(AIMAG(XLAM).LT.AIMAG(EIG(I)))XLAM=EIG(I)                       COSAL    1406
   15 CONTINUE                                                          COSAL    1407
      WRITE(6,4)XLAM                                                    COSAL    1408
      RETURN                                                            COSAL    1409
      END                                                               COSAL    1410
      SUBROUTINE FLOW(NWANT,NZ)                                         COSAL    1411
      REAL MACH,MUE                                                     COSAL    1412
      DIMENSION X(102),U(102),U1(102),U2(102),W(102),W1(102),W2(102),   COSAL    1413
     1 T(102),T1(102),T2(102)                                           COSAL    1414
      DIMENSION UE(1)                                                   COSAL    1415
      COMMON /MFLO/ KPTS,X,U,U1,U2,W,W1,W2,T,T1,T2                      COSAL    1416
      COMMON /EDGE/ TE,MUE,UE                                           COSAL    1417
      COMMON /PROP/ XMACH,GAMA,REY,PRANDTL,STOKES,DSTZ                  COSAL    1418
      COMMON /XMP/ MACH                                                 COSAL    1419
      COMMON /GG/ G,XL,XY                                               COSAL    1420
      COMMON /PRINTS/ IPR1                                              COSAL    1421
   10 CONTINUE                                                          COSAL    1422
      READ(7) NZ,NNP,DSTZ,REY                                           COSAL    1423
      READ(7) QE,PE,TE,RHOE,MUE,TW,RHOW                                 COSAL    1424
      READ(7) (X (J),J=1,NNP)                                           COSAL    1425
      READ(7) (U (J),J=1,NNP)                                           COSAL    1426
      READ(7) (U1(J),J=1,NNP)                                           COSAL    1427
      READ(7) (U2(J),J=1,NNP)                                           COSAL    1428
      READ(7) (W (J),J=1,NNP)                                           COSAL    1429
      READ(7) (W1(J),J=1,NNP)                                           COSAL    1430
      READ(7) (W2(J),J=1,NNP)                                           COSAL    1431
      READ(7) (T (J),J=1,NNP)                                           COSAL    1432
      READ(7) (T1(J),J=1,NNP)                                           COSAL    1433
      READ(7) (T2(J),J=1,NNP)                                           COSAL    1434
      IF(NZ.LT.NWANT) GO TO 10                                          COSAL    1435
      KPTS=NNP+1                                                        COSAL    1436
      U(KPTS)=1.                                                        COSAL    1437
      U1(KPTS)=0.                                                       COSAL    1438
      U2(KPTS)=0.                                                       COSAL    1439
                                                                        COSAL    1440
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      W(KPTS)=W(KPTS-1)                                                 COSAL
      W1(KPTS)=0.                                                       COSAL
      W2(KPTS)=0.                                                       COSAL
      T(KPTS)=1.                                                        COSAL
      T1(KPTS)=0.                                                       COSAL
      T2(KPTS)=0.                                                       COSAL
      X(KPTS)=X(KPTS-1)+1.0                                             COSAL
      MUE=2.27E-8*TE**1.5/(TE+198.6)                                    COSAL
      MACH=UE(NZ)/SQRT(32.2*53.3*GAMA*TE)                               COSAL
      XMACH=MACH*MACH                                                   COSAL
      IF(IPP1.NE.1)RETURN                                               COSAL
      WRITE(6,15)                                                       COSAL
      WRITE(6,16)                                                       COSAL
      WRITE(6,17)(J,X(J),U(J),U1(J),U2(J),W(J),W1(J),W2(J),T(J),        COSAL
     1 T1(J),T2(J),J=1,KPTS)                                            COSAL
15    FORMAT(///,5X,*MEAN FLOW PROFILES RECEIVED FROM TAPE7 ARE :*,//)  COSAL
16     FORMAT(4X,*J*,6X,*Y*,11X,*U*,11X,*U1*,10X,*U2*,10X,*W*,11X,*W1*, COSAL
     1 10X,*W2*,10X,*T*,11X,*T1*,10X,*T2*,/)                            COSAL
17    FORMAT(1X,I5,10G12.5)                                             COSAL
      RETURN                                                            COSAL
      END                                                               COSAL
      SUBROUTINE LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,         COSAL
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)                                  COSAL
      DIMENSION CSP(1),WORK(1),IP(M,1),IC(M,1)                          COSAL
      COMPLEX UU(M,1),UWRK(M,1),VV(M,1),VWRK(M,1)                       COSAL
      COMPLEX A(M,M,1),B(M,M,1),AA(M,M,1),BB(M,M,1),CC(M,M,1)           COSAL
      COMPLEX DENOM,XLAM,VA,VB,VA1,VB1,VA2,VB2,XLAM1,XLAM2,XLAM3        COSAL
      COMMON /LOCAL/ LLL,NPASS,INTRPOL,IPRZ                             COSAL
      COMMON /GLOBE/ ILOC                                               COSAL
      COMMON /FUN/ JPASS                                                COSAL
      COMMON /PRINTS/ IPR1,IPP2,IPR3,IPR4,IPR5,IPR6,IPR7                COSAL
      ILOC=0                                                            COSAL
      NCP=NC                                                            COSAL
      NTEMP=NC                                                          COSAL
      PI=4.*ATAN(1.)                                                    COSAL
      NM=NC-1                                                           COSAL
      PIN=PI/NM                                                         COSAL
      DO 11 II=1,NC                                                     COSAL
      DO 11 JJ=1,M                                                      COSAL
      UU(JJ,II)=COS(PIN*FLOAT(II-1))**2-1.                              COSAL
      VV(JJ,II)=UU(JJ,II)                                               COSAL
11     CONTINUE                                                         COSAL
      IPASS=0                                                           COSAL
677   IPASS=IPASS+1                                                     COSAL
      CALL FLOWMAP(NC,CSP)                                              COSAL
      IF(IPASS.NE.1)CALL INTERP(WORK,NC1,CSP,NC,UU,UWRK,M)              COSAL
      IF(IPASS.NE.1)CALL INTERP(WORK,NC1,CSP,NC,VV,UWRK,M)              COSAL
      CALL ZIGZAG(A,B,AA,BB,CC,M,NC,LLL,UU,UWRK,VV,VWRK,IR,IC,          COSAL
       )
```

```
      1 ALPHA,BETA,XLAM,NPASS,DENOM)
        CALL GRPVEL(A,B,UU,UWRK,VV,VWRK,M,NC,VA,VB,ALPHA,BETA,XLAM,
      1 DENOM)
        IF(IPASS.NE.1)GO TO 344
        IF(INTRPOL.EQ.1)GO TO 790
        XLAM1=XLAM
        VA1=VA
        VB1=VB
        H1=1./FLOAT(NC-1)**2
        NC1=NC
        DO 55 I=1,NC1
   55   WORK(I)=CSP(I)
        NC=NC+IPRZ
        PIN=PI/(NC-1)
        NM=NC-1
        GO TO 677
  344   IF(IPASS.EQ.3)GO TO 341
        XLAM2=XLAM
        VA2=VA
        VB2=VB
        H2=1./FLOAT(NC-1)**2
        NC1=NC
        DO 56 I=1,NC
   56   WORK(I)=CSP(I)
        NC=NC+IPRZ
        PIN=PI/(NC-1)
        NM=NC-1
        GO TO 677
  341   CONTINUE
        H3=1./FLOAT(NC-1)**2
        XLAM3=XLAM
        H231=(H2-H3)/H1
        H312=(H3-H1)/H2
        H123=(H1-H2)/H3
        HDENOM=1./(H231+H312+H123)
        XLAM=(H231*XLAM1+H312*XLAM2+H123*XLAM3)*HDENOM
        VA=(H231*VA1+H312*VA2+H123*VA)*HDENOM
        VB=(H231*VB1+H312*VB2+H123*VB)*HDENOM
        NCP=NC
        NC=NTEMP
  790   CONTINUE
        JPASS=1
        IF(IPR3.EQ.0)GO TO 200
        WRITE(6,557)ALPHA,BETA
        IF(INTRPOL.EQ.1)GO TO 200
        WRITE(6,222)XLAM
        WRITE(6,256)VA,VB
  200   CONTINUE
```

```
      IF(IPR4.EQ.0)RETURN                                                COSAL
      IF(M.NE.5)WRITE(6,120)                                             COSAL
      IF(M.NE.5)RETURN                                                   COSAL
      ALBT=ALPHA*ALPHA+BETA*BETA                                         COSAL
      DO 130 I=1,NCP                                                     COSAL
      UWRK(1,1)=(ALPHA*UU(1,I)-BETA*UU(M,I))/ALBT                        COSAL
      UWRK(2,1)=(BETA*UU(1,I)+ALPHA*UU(M,I))/ALBT                        COSAL
      UU(1,I)=UWRK(1,1)                                                  COSAL
  130 UU(M,I)=UWRK(2,1)                                                  COSAL
      UWRK(1,1)=0.                                                       COSAL
      MNC=M*NCP                                                          COSAL
      DO 140 I=1,MNC                                                     COSAL
      IF(CABS(UU(I)).LT.CABS(UWRK(1,1)))GO TO 140                        COSAL
      UWRK(1,1)=UU(I)                                                    COSAL
  140 CONTINUE                                                           COSAL
      UWRK(1,1)=1./UWRK(1,1)                                             COSAL
      DO 150 I=1,MNC                                                     COSAL
  150 UU(I)=UU(I)*UWRK(1,1)                                              COSAL
      NCM1=NCP-1                                                         COSAL
      DO 155 I=2,NCM1                                                    COSAL
  155 UWRK(1,I)=0.5*(UU(3,I)+UU(3,I-1))                                  COSAL
      UWRK(1,NCP)=UWRK(1,NCM1)                                           COSAL
      DENOM=UU(3,1)-UU(3,2)                                              COSAL
      I2=2                                                               COSAL
      I3=3                                                               COSAL
      YY1=0.5*(CSP(1)+CSP(I2))                                           COSAL
      YY2=0.5*(CSP(I2)+CSP(I3))                                          COSAL
      DENOM=0.5*DENOM/(YY1-YY2)                                          COSAL
      YY2=CSP(1)-YY1                                                     COSAL
      UWRK(1,1)=UU(3,1)+DENOM*YY2                                        COSAL
      DO 156 I=1,NCP                                                     COSAL
  156 UU(3,I)=UWRK(1,I)                                                  COSAL
      WRITE(6,160)                                                       COSAL
      WRITE(6,170)(J,CSP(J),UU(1,J),UU(2,J),UU(3,J),UU(4,J),UU(5,J),     COSAL
     1 J=1,NCP)                                                          COSAL
  120 FORMAT(///,5X,*$$ M SHOULD BE 5 FOR EIGENFUNCTION CALCULATION $$*  COSAL
     1 ,)                                                                COSAL
  160 FORMAT(///,5X,*$$EIGENFUNCTION PRINTED. THE ORDER OF PRINT IS $*,  COSAL
     1//,9X,*J,Y(J),U(J),V(J),P(J),T(J) AND W(J) . NOTE THAT U,V,P,T ANDCOSAL
     2*,/,9X,*W ARE COMPLEX.$$*,//)                                      COSAL
  170 FORMAT(1X,I5,11G11.4)                                              COSAL
  256   FORMAT(1X,*VA =*,2G14.7,5X,*VB =*,2G14.7)                        COSAL
 222  FORMAT(1X,*EXTRAPOLATED VALUE=*,2G20.13)                           COSAL
  557   FORMAT(1X,*ALPHA= *,G13.5,5X,*BETA= *,G13.5)                     COSAL
      RETURN                                                             COSAL
      END                                                                COSAL
      SUBROUTINE FLOWMAP(NC,CSP)                                         COSAL
      REAL MUE                                                           COSAL
```

```
      DIMENSION DUM1(101),DUM2(101),DUM3(101),DUM4(101),DUM5(101),
     1 DUM6(101),DUM7(101),DUM8(101),DUM9(101),DUM10(101),DUM11(101),
     2 DUM12(101)
      COMMON /DUMY/ DUM1,DUM2,DUM3,DUM4,DUM5,DUM6,DUM7,DUM8,DUM9,DUM10,
     1DUM11,DUM12
      DIMENSION X(102),U(102),U1(102),U2(102),W(102),W1(102),W2(102),
     1 T(102),T1(102),T2(102)
      DIMENSION XX(1),CSP(1)
      COMMON /MFLO/ KPTS,X,U,U1,U2,W,W1,W2,T,T1,T2
      COMMON /EDGE/ TE,MUE
      COMMON /GG/ G,XL,XX
      COMMON /PRINTS/ IPR1,IPR2,IPR3,IPR4,IPR5
      NM=NC-1
      KO=0
      DO 2 I=1,NC
      XX(I)=1.-FLOAT(I-1)/FLOAT(NM)
      CSP(I)=XL*XX(I)/(G-XX(I))
      IF(CSP(I).GT.X(KPTS))GO TO 2
      KO=KO+1
      DUM10(KO)=CSP(I)
    2 CONTINUE
      DO 3 I=1,NC
      IF(CSP(I).LT.X(KPTS))GO TO 4
    3 CONTINUE
    4 NI=I
      NN=NC-NI+1
      CALL BSLINT(0,3,X,U,KPTS,DUM10,DUM1,NN )
      CALL BSLINT(0,3,X,U1,KPTS,DUM10,DUM2,NN )
      CALL BSLINT(0,3,X,U2,KPTS,DUM10,DUM3,NN )
      CALL BSLINT(0,3,X,W,KPTS,DUM10,DUM4,NN )
      CALL BSLINT(0,3,X,W1,KPTS,DUM10,DUM5,NN )
      CALL BSLINT(0,3,X,W2,KPTS,DUM10,DUM6,NN )
      CALL BSLINT(0,3,X,T,KPTS,DUM10,DUM7,NN)
      CALL BSLINT(0,3,X,T1,KPTS,DUM10,DUM8,NN)
      CALL BSLINT(0,3,X,T2,KPTS,DUM10,DUM9,NN)
      DO 5 I=1,NN
      K1=NC-I+1
      K2=NN-I+1
      DUM1(K1)=DUM1(K2)
      DUM2(K1)=DUM2(K2)
      DUM3(K1)=DUM3(K2)
      DUM4(K1)=DUM4(K2)
      DUM5(K1)=DUM5(K2)
      DUM6(K1)=DUM6(K2)
      DUM7(K1)=DUM7(K2)
      DUM8(K1)=DUM8(K2)
    5 DUM9(K1)=DUM9(K2)
      NIM=NI-1
```

```
      DO 6 I=1,NIM
      DUM1(I)=DUM7(I)=1.
      DUM2(I)=DUM3(I)=DUM5(I)=DUM6(I)=DUM8(I)=DUM9(I)=0.
    6 DUM4(I)=DUM4(1)
      DO 11 J=1,NC
      DUM11(J)=2.27E-8*(DUM7(J)*TE)**0.5*(0.5*DUM7(J)*TE+297.9)/
     1 (DUM7(J)*TE+198.6)**2/MUE
      DUM12(J)=(1.7025E-8/(DUM7(J)*TE)**0.5-2.*DUM11(J)*MUE)/
     1 (DUM7(J)*TE+198.6)/MUE
      DUM10(J)=2.27E-8*(DUM7(J)*TE)**1.5/(DUM7(J)*TE+198.6)/MUE
      DUM11(J)=DUM11(J)*TE
      DUM12(J)=DUM12(J)*TE*TE
   11 CONTINUE
      IF(IPR5.EQ.0)RETURN
      WRITE(6,15)
      WRITE(6,16)

      WRITE(6,17)(J,CSP(J),DUM1(J),DUM2(J),DUM3(J),DUM4(J),DUM5(J),
     1 DUM6(J),DUM7(J),DUM8(J),DUM9(J),J=1,NC)
   15  FORMAT(///,5X,*MEAN FLOW PROFILES INTERPOLATED TO THE COMPUTATION
     1AL GRID ARE :*,//)
   16  FORMAT(4X,*J*,6X,*Y*,11X,*U*,11X,*U1*,10X,*U2*,10X,*W*,11X,*W1*,
     1 10X,*W2*,10X,*T*,11X,*T1*,10X,*T2*,/)
   17 FORMAT(1X,I5,10G12.5)
      RETURN
      END
      SUBROUTINE INTERP(X,NX,Y,NY,U,US,M)
      COMPLEX  U(M,1),US(M,1)
      DIMENSION WORK(1)
      DIMENSION X(1),Y(1)
      COMMON /DUMWRK/ TR(101),TA(101),ZR(101),ZA(101)
      NXM1=NX-1
      DO 20 I=2,NXM1
   20 US(1,I)=0.5*(U(3,I)+U(3,I-1))
      US(1,NX)=U(3,NX)
      US(2,1)=U(3,1)-U(3,2)
      I2=2
      I3=3
      YY1=(X(1)+X(I2))*0.5
      YY2=(X(I2)+X(I3))*0.5
      US(2,1)=0.5*US(2,1)/(YY1-YY2)
      YY2=X(1)-YY1
      US(1,1)=U(3,1)+US(2,1)*YY2
      DO 25 I=1,NY
   25 U(3,I)=US(1,I)
      DO 1 I=1,M
      DO 1 J=1,NX
    1 US(I,J)=U(I,J)
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      DO 3 I=1,M                                                COSAL  1681
      DO 9 J=1,NX                                               COSAL  1682
      TR(J)=REAL(US(I,J))                                       COSAL  1683
      TA(J)=AIMAG(US(I,J))                                      COSAL  1684
    9   CONTINUE                                                COSAL  1685
      CALL BSLINT(0,3,X,TA,NX,Y,ZA,NY)                          COSAL  1686
      CALL BSLINT(0,3,X,TR,NX,Y,ZR,NY)                          COSAL  1687
      DO 10 J=1,NY                                              COSAL  1688
      U(I,J)=CMPLX(ZR(J),ZA(J))                                 COSAL  1689
   10 CONTINUE                                                  COSAL  1690
    3  CONTINUE                                                 COSAL  1691
      NYM1=NY-1                                                 COSAL  1692
      DO 30 I=1,NYM1                                            COSAL  1693
   30 US(1,I)=0.5*(U(3,I)+U(3,I+1))                             COSAL  1694
      DO 35 I=1,NYM1                                            COSAL  1695
   35 U(3,I)=US(1,I)                                            COSAL  1696
      RETURN                                                    COSAL  1697
      END                                                       COSAL  1698
      SUBROUTINE CMULT(A,B,C,M,NDIM)                            COSAL  1699
      COMPLEX A(NDIM,1),B(NDIM,1),C(NDIM,1)                     COSAL  1700
      DO 1 I=1,M                                                COSAL  1701
      DO 1 J=1,M                                                COSAL  1702
      C(I,J)=0.0                                                COSAL  1703
      DO 1 K=1,M                                                COSAL  1704
    1 C(I,J)=C(I,J)+A(I,K)*B(K,J)                               COSAL  1705
      RETURN                                                    COSAL  1706
      END                                                       COSAL  1707
      SUBROUTINE AX(A,X,Y,N,NDIM)                               COSAL  1708
      COMPLEX A(NDIM,1),X(1),Y(1)                               COSAL  1709
      DO 2 I=1,N                                                COSAL  1710
      Y(I)=0.                                                   COSAL  1711
      DO 1 J=1,N                                                COSAL  1712
    1 Y(I)=Y(I)+A(I,J)*X(J)                                     COSAL  1713
    2 CONTINUE                                                  COSAL  1714
      RETURN                                                    COSAL  1715
      END                                                       COSAL  1716
      SUBROUTINE ATX(A,X,Y,N,NDIM)                              COSAL  1717
      COMPLEX A(NDIM,1),X(1),Y(1)                               COSAL  1718
      DO 2 I=1,N                                                COSAL  1719
      Y(I)=0.                                                   COSAL  1720
      DO 1 J=1,N                                                COSAL  1721
    1 Y(I)=Y(I)+A(J,I)*X(J)                                     COSAL  1722
    2 CONTINUE                                                  COSAL  1723
      RETURN                                                    COSAL  1724
      END                                                       COSAL  1725
      SUBROUTINE BLKLU(A,B,C,N,M,M2,IR,IC,F)                    COSAL  1726
C     SOLVES N BLOCK TRIDIAGONAL EQUATIONS WITH M X M BLOCKS    COSAL  1727
C     NOTE THAT M2 = M**2                                       COSAL  1728
```

```
      COMPLEX A(M2,1),B(M2,1),C(M2,1)                                   COSAL    1729
      COMPLEX D(100),F(M,1)                                             COSAL    1730
C     IF M IS GREATER THAN 10, D ARRAY MUST BE REDIMENSIONED            COSAL    1731
      DIMENSION IR(M,1),IC(M,1)                                         COSAL    1732
      CALL LU(B,M,M,IR,IC)                                              COSAL    1733
      DO 1 I=2,N                                                        COSAL    1734
      CALL SOLVE(C(1,I-1),B(1,I-1),M,M,M,IR(1,I-1),IC(1,I-1))           COSAL    1735
      CALL CMULT(A(1,I),C(1,I-1),D,M,M)                                 COSAL    1736
      DO 2 J=1,M2                                                       COSAL    1737
2     B(J,I)=B(J,I)-D(J)                                                COSAL    1738
1     CALL LU(B(1,I),M,M,IR(1,I),IC(1,I))                               COSAL    1739
      RETURN                                                            COSAL    1740
      ENTRY BLKSOLV                                                     COSAL    1741
      CALL SOLVE(F,B,1,M,M,IR,IC)                                       COSAL    1742
      DO 3 I=2,N                                                        COSAL    1743
      CALL AX(A(1,I),F(1,I-1),D,M,M)                                    COSAL    1744
      DO 4 K=1,M                                                        COSAL    1745
4     F(K,I)=F(K,I)-D(K)                                                COSAL    1746
3     CALL SOLVE(F(1,I),B(1,I),1,M,M,IR(1,I),IC(1,I))                   COSAL    1747
      DO 5 II=2,N                                                       COSAL    1748
      I=N+1-II                                                          COSAL    1749
      CALL AX(C(1,I),F(1,I+1),D,M,M)                                    COSAL    1750
      DO 5 J=1,M                                                        COSAL    1751
5     F(J,I)=F(J,I)-D(J)                                                COSAL    1752
      RETURN                                                            COSAL    1753
      ENTRY BLKTPN                                                      COSAL    1754
C     SOLUTION OF TRANSPOSE EQUATION                                    COSAL    1755
      DO 30 I=2,N                                                       COSAL    1756
      CALL ATX(C(1,I-1),F(1,I-1),D,M,M)                                 COSAL    1757
      DO 31 J=1,M                                                       COSAL    1758
31    F(J,I)=F(J,I)-D(J)                                                COSAL    1759
30    CONTINUE                                                          COSAL    1760
      CALL SOLVTPN(F(1,N),B(1,N),M,M ,IR(1,N),IC(1,N))                  COSAL    1761
      DO 32 II=2,N                                                      COSAL    1762
      I=N+1-II                                                          COSAL    1763
      CALL ATX(A(1,I+1),F(1,I+1),D,M,M)                                 COSAL    1764
      DO 33 J=1,M                                                       COSAL    1765
33    F(J,I)=F(J,I)-D(J)                                                COSAL    1766
      CALL SOLVTPN(F(1,I),B(1,I),M,M ,IR(1,I),IC(1,I))                  COSAL    1767
32    CONTINUE                                                          COSAL    1768
      RETURN                                                            COSAL    1769
      END                                                               COSAL    1770
      SUBROUTINE ZIGZAG(A,B,AA,BB,CC,M,NP1,LLL,U,UWRK,V,VWRK,IR,IC,     COSAL    1771
     1AL,BL,OMEGA,NPASS,H)                                              COSAL    1772
C     FINDS CORRECTIONS TO EIGENVALUES OF D*D+A*D+B                     COSAL    1773
C     WHERE A AND B DEPEND ON THE EIGENVALUE OMEGA                      COSAL    1774
      DIMENSION IR(M,1),IC(M,1)                                         COSAL    1775
      COMPLEX A(M,M,1),B(M,M,1),AA(M,M,1),BB(M,M,1),CC(M,M,1),          COSAL    1776
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      1U(M,1),UWRK(M,1),V(M,1),VWRK(M,1)
       COMPLEX LAMBDA,G,H,OMEGA,FAC,FACT
       COMMON /PRINTS/ IPR1,IPR2,IPR3
       EPSLON=.01
       CON=1.E-06
        NM=NP1-1
       M2=M**2
       III=M*NM
       ICOUNT=0
 500       ICOUNT=ICOUNT+1
       CALL  GSET(AL,BL,OMEGA,M,NP1,A,0,0)
       CALL  GSET(AL,BL,OMEGA,M,NP1,B,1,0)
       CALL  BOUNDRY(IR,IC,M)
       CALL  ABCSET(A,B,M,NP1,AA,BB,CC,0)
        CALL  BLKLU(AA,BB,CC,NM,M,M2,IR,IC,G)
       L=0
  502  L=L+1
       CALL  GSET(AL,BL,OMEGA,M,NP1,B,1,1)
       CALL  FDFVAL(U,UWRK,V,VWRK,M,NP1,0,0,A,B)
       IF(L.GE.LLL)GO TO 501
       IF(L.LE.2)GO TO 601
       IF(ABS(REAL(FAC)).LT.CON.AND.ABS(AIMAG(FAC)).LT.CON)GO TO 501
       FR1=REAL(FAC)
       FRT=REAL(FACT)
       FI1=AIMAG(FAC)
       FIT=AIMAG(FACT)
       FACT=FAC
       IF(ABS(FR1/FRT-1.).GT.EPSLON)GO TO 601
       IF(ABS(FI1/FIT-1.).LE.EPSLON)GO TO 501
 601    CONTINUE
       IF(ICOUNT.EQ.1.OR.L.EQ.1)GO TO 602
       IF(ABS(REAL(FAC)).LT.CON.AND.ABS(AIMAG(FAC)).LT.CON)GO TO 501
  602   CONTINUE
       CALL  BLKSOLV(AA,BB,CC,NM,M,M2,IR,IC,UWRK)
       CALL  BLKTRN(AA,BB,CC,NM,M,M2,IR,IC,VWRK)
       FAC=0.
       DO 200 I=1,III
       IF(CABS(UWRK(I)).LT.CABS(FAC))GO TO 200
       FAC=UWRK(I)
 200   CONTINUE
       FAC=1./FAC
       IF(L.EQ.1)FACT=FAC
       IF(IPR3.NE.1)GO TO 221
       WRITE(6,37)ICOUNT,L,NM
  37   FORMAT(1X,* NPASS =*,I3,5X,* L =*,I3,5X,*N =*,I3)
       WRITE(6,449)FAC
  449  FORMAT(1X,*FAC=*,2E20.13)
  221   CONTINUE
```

```
      DO 203 I=1,III                                                    COSAL    1825
      V(I,1)=VWRK(I)*FAC                                                COSAL    1826
  203 U(I,1)=UWRK(I)*FAC                                                COSAL    1827
      GO TO 502                                                         COSAL    1828
  501 EPS=.001                                                          COSAL    1829
      CALL GSET(AL,BL,OMEGA,M,NP1,A,0,0)                                COSAL    1830
      CALL GSET(AL,BL,OMEGA,M,NP1,B,1,0)                                COSAL    1831
      CALL FDEVAL(U,VWRK,U,VWRK,M,NP1,1,0,A,B)                          COSAL    1832
      G=0.                                                              COSAL    1833
      H=0.                                                              COSAL    1834
      DO 10 I=1,III                                                     COSAL    1835
      G=G+V(I,1)*VWRK(I,1)                                              COSAL    1836
   10 H=H+V(I,1)*UWRK(I,1)                                              COSAL    1837
      LAMBDA=G/H                                                        COSAL    1838
      OMEGA=OMEGA-LAMBDA                                                COSAL    1839
      IF(IPR3.EQ.1)WRITE(6,45)ICOUNT,LAMBDA,OMEGA                       COSAL    1840
      IF(ICOUNT.LT.NPASS)GO TO 500                                      COSAL    1841
   45 FORMAT(1X,*NPASS=*,I5,5X,*LAMBDA=*,2E15.8,/,*$$$$$$$$$$$$$$$$$$$*  COSAL    1842
     1,*OMEGA=*,2E15.8)                                                 COSAL    1843
      RETURN                                                            COSAL    1844
      END                                                               COSAL    1845
      SUBROUTINE FDEVAL(U,UWRK,V,VWRK,M,NP1,ISW,IFD,A,B)                COSAL    1846
      COMPLEX U(M,1),UWRK(M,1),V(M,1),VWRK(M,1),A(M,M,1),B(M,M,1)       COSAL    1847
      DIMENSION X(1)                                                    COSAL    1848
        COMMON /GG/G,XL,X                                               COSAL    1849
      NM=NP1-1                                                          COSAL    1850
      IF(ISW.EQ.0.AND.IFD.EQ.0)GO TO 101                                COSAL    1851
      FC1=ISW-IFD                                                       COSAL    1852
      FG=1./(XL*G)                                                      COSAL    1853
      FF=2.*FG**2                                                       COSAL    1854
      DO 1 K=1,NM                                                       COSAL    1855
      CALL ZMAP(K,X,G,FG,FF,XF,XF1,XF2,XB2,XC2)                         COSAL    1856
      DO 2 I=1,M                                                        COSAL    1857
      IF(I.EQ.3)GO TO 5                                                 COSAL    1858
      IF(K.EQ.1)GO TO 2                                                 COSAL    1859
      UWRK(I,K)=(XB2*U(I,K-1)+XC2*U(I,K)+XF2*U(I,K+1))*FC1              COSAL    1860
      DO 9 J=1,M                                                        COSAL    1861
      IF(J.EQ.3)GO TO 8                                                 COSAL    1862
      UWRK(I,K)=UWRK(I,K)+A(I,J,K)*XF*(U(J,K+1)-U(J,K-1))               COSAL    1863
      GO TO 9                                                           COSAL    1864
    8 UWRK(I,K)=UWRK(I,K)+A(I,J,K)*2.*XF*(U(J,K)-U(J,K-1))              COSAL    1865
    9 CONTINUE                                                          COSAL    1866
      GO TO 2                                                           COSAL    1867
    5 UWRK(I,K)=0.                                                      COSAL    1868
      DO 13 J=1,M                                                       COSAL    1869
   13 UWRK(I,K)=UWRK(I,K)+0.5*(A(I,J,K)+A(I,J,K+1))*XF1*                COSAL    1870
     1 (U(J,K+1)-U(J,K))                                                COSAL    1871
    2 CONTINUE                                                          COSAL    1872
```

```
1        CONTINUE
      GO TO 105
 101  DO 100 I=1,M
      DO 100 K=1,NM
      UWRK(I,K)=0.
      IF(ISW.EQ.0)VWRK(I,K)=0.
 100  CONTINUE
 105  CONTINUE
      DO 21 K=1,NM
      DO 22 I=1,M
      IF(I.EQ.3)GO TO 10
      IF(K.EQ.1)GO TO 22
      DO 23 J=1,M
      IF(J.EQ.3)GO TO 26
      UWRK(I,K)=UWRK(I,K)+B(I,J,K)*U(J,K)
      IF(ISW.EQ.0)VWRK(I,K)=VWRK(I,K)+B(J,I,K)*V(J,K)
      GO TO 23
26     UWRK(I,K)=UWRK(I,K)+0.5*B(I,J,K)*(U(J,K)+U(J,K-1))
      IF(ISW.EQ.0)VWRK(I,K)=VWRK(I,K)+0.5*B(J,I,K)*(V(J,K)+V(J,K-1))
23     CONTINUE
        GO TO 22
10      DO 11 J=1,M
        IF(J.EQ.3)GO TO 14
        UWRK(I,K)=UWRK(I,K)+0.25*(B(I,J,K)+B(I,J,K+1))*(U(J,K)+U(J,K+1))
        IF(ISW.EQ.0)VWRK(I,K)=VWRK(I,K)+0.25*(B(J,I,K)+B(J,I,K+1))*
     1 (V(J,K)+V(J,K+1))
        GO TO 11
14      UWRK(I,K)=UWRK(I,K)+0.5*(B(I,J,K)+B(I,J,K+1))*U(J,K)
        IF(ISW.EQ.0)VWRK(I,K)=VWRK(I,K)+0.5*(B(J,I,K)+B(J,I,K+1))*V(J,K)
11      CONTINUE
 22      CONTINUE
 21      CONTINUE
      DO 30 J=1,M
      IF(J.EQ.3)GO TO 30
       UWRK(I,1)=0.
30     CONTINUE
      RETURN
      END
      SUBROUTINE GRPVEL(A,B,U,UWRK,V,VWRK,M,NP1,VA,VB,ALPHA,BETA,OMEGA,
     1 DENOM)
      COMPLEX U(M,1),UWRK(M,1),V(M,1),VWRK(M,1),A(M,M,1),B(M,M,1)
      COMPLEX VA,VB,DENOM
      COMMON /PRINTS/ IPR1,IPR2,IPR3
      NT1=M*(NP1-1)
      CALL DLDK(ALPHA,BETA,OMEGA,M,NP1,A,0,1.,0.,ALPHA)
      CALL DLDK(ALPHA,BETA,OMEGA,M,NP1,B,1,1.,0.,ALPHA)
      CALL EDEVAL(U,UWRK,U,UWRK,M,NP1,1,1,A,B)
      CALL DLDK(ALPHA,BETA,OMEGA,M,NP1,A,0,0.,1.,BETA)
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```
      CALL DLOK(ALPHA,BETA,OMEGA,M,NP1,B,1,0.,1.,BETA)
      CALL FDEVAL(U,VWRK,U,VWRK,M,NP1,1,1,A,B)
      VA=0.
      VB=0.
      DO 2 I=1,NT1
      VA=VA+V(I,1)*UWRK(I,1)
    2 VB=VB+V(I,1)*VWRK(I,1)
      VA=-VA/DENOM
      VB=-VB/DENOM
      IF(IPP3.EQ.0)RETURN
      WRITE(6,3)VA,VB
    3 FORMAT(5X,*VA = *,2G15.7,5X,*VB = *,2G15.7)
      RETURN
      END
      SUBROUTINE ABCSET(A,B,M,NP1,AA,BB,CC,IAB)
C      SETS UP BLOCK TRIDIAGONAL STRUCTURE FOR (D**2+A*D+B)
      COMPLEX A(M,M,1),B(M,M,1),AA(M,M,1),BB(M,M,1),CC(M,M,1),FAC
      DIMENSION Y(1)
      COMMON /BDRY/BNDRY
      COMMON/ GLOBE/ ILOC
      COMPLEX BNDRY(4,8)
      COMMON /GG/G,XL,X
      FG=1./(XL*G)
      FF=2.*FG**2
      NM=NP1-1
      IF(IAB.EQ.1)GO TO 301
      DO 1 K=1,NM
      CALL ZMAP(K,X,G,FG,FF,XF,XF1,XF2,XB2,XC2)
      DO 20 I=1,M
      IF(I.EQ.3)GO TO 11
      IF(K.EQ.1)GO TO 20
      DO 4 J=1,M
      IF(J.EQ.3)GO TO 10
      BB(I,J,K)=B(I,J,K)
      CC(I,J,K)=A(I,J,K)*XF
      AA(I,J,K)=-CC(I,J,K)
      GO TO 4
   10 IF(I.EQ.2)GO TO 12
      CC(I,J,K)=0.
      BB(I,J,K)=0.5*B(I,J,K)
      AA(I,J,K)=BB(I,J,K)
      GO TO 4
   12 BB(I,J,K)=2.*A(I,J,K)*XF
      AA(I,J,K)=-BB(I,J,K)
      CC(I,J,K)=0.
    4 CONTINUE
      DO 7 J=1,M
      IF(I.NE.J)GO TO 7
```

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      AA(I,J,K)=AA(I,J,K)+XR2                                           COSAL   1969
      BB(I,J,K)=BB(I,J,K)+XC2                                           COSAL   1970
      CC(I,J,K)=CC(I,J,K)+XF2                                           COSAL   1971
    7 CONTINUE                                                          COSAL   1972
      GO TO 20                                                          COSAL   1973
   11 DO 8 J=1,M                                                        COSAL   1974
      IF(J.EQ.3)GO TO 13                                                COSAL   1975
      CC(I,J,K)=0.5*(A(I,J,K)+A(I,J,K+1))*XF1                           COSAL   1976
      BB(I,J,K)=-CC(I,J,K)                                              COSAL   1977
      AA(I,J,K)=0.                                                      COSAL   1978
      FAC=0.25*(B(I,J,K)+B(I,J,K+1))                                    COSAL   1979
      CC(I,J,K)=CC(I,J,K)+FAC                                           COSAL   1980
      BB(I,J,K)=BB(I,J,K)+FAC                                           COSAL   1981
      GO TO 8                                                           COSAL   1982
   13 BB(I,J,K)=0.5*(B(I,J,K)+B(I,J,K+1))                               COSAL   1983
      AA(I,J,K)=CC(I,J,K)=0.                                            COSAL   1984
    8 CONTINUE                                                          COSAL   1985
   20 CONTINUE                                                          COSAL   1986
    1  CONTINUE                                                         COSAL   1987
      GO TO 201                                                         COSAL   1988
  301 CONTINUE                                                          COSAL   1989
      DO 61 K=1,NM                                                      COSAL   1990
      DO 40 I=1,M                                                       COSAL   1991
      IF(I.EQ.3)GO TO 31                                                COSAL   1992
      IF(K.EQ.1)GO TO 40                                                COSAL   1993
      DO 24 J=1,M                                                       COSAL   1994
      IF(J.EQ.3)GO TO 30                                                COSAL   1995
      BB(I,J,K)=B(I,J,K)                                                COSAL   1996
      AA(I,J,K)=CC(I,J,K)=0.                                            COSAL   1997
      GO TO 24                                                          COSAL   1998
   30 BB(I,J,K)=0.5*B(I,J,K)                                            COSAL   1999
      AA(I,J,K)=BB(I,J,K)                                               COSAL   2000
      CC(I,J,K)=0.                                                      COSAL   2001
   24 CONTINUE                                                          COSAL   2002
      GO TO 40                                                          COSAL   2003
   31 DO 28 J=1,M                                                       COSAL   2004
      IF(J.EQ.3)GO TO 33                                                COSAL   2005
      FAC=0.25*(B(I,J,K)+B(I,J,K+1))                                    COSAL   2006
      CC(I,J,K)=FAC                                                     COSAL   2007
      BB(I,J,K)=FAC                                                     COSAL   2008
      AA(I,J,K)=0.                                                      COSAL   2009
      GO TO 28                                                          COSAL   2010
   33 BB(I,J,K)=0.5*(B(I,J,K)+B(I,J,K+1))                               COSAL   2011
      AA(I,J,K)=CC(I,J,K)=0.                                            COSAL   2012
   28 CONTINUE                                                          COSAL   2013
   40 CONTINUE                                                          COSAL   2014
   61 CONTINUE                                                          COSAL   2015
C     FREE STREAM BOUNDARY CONDITIONS                                   COSAL   2016
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```
201   IF(ILOC.EQ.0)GO TO 601                                    COSAL   2017
      DO 1002 I=1,M                                             COSAL   2018
      DO 1002 J=1,M                                             COSAL   2019
      IF(I.EQ.3)GO TO 1002                                      COSAL   2020
      BB(I,J,1)=CC(I,J,1)=0.                                    COSAL   2021
      IF(I.EQ.J)BB(I,J,1)=1.                                    COSAL   2022
1002  CONTINUE                                                  COSAL   2023
       RETURN                                                   COSAL   2024
 601   CONTINUE                                                 COSAL   2025
      XX=G-X(1)                                                 COSAL   2026
      I2=2                                                      COSAL   2027
      XO=XX**2*FG/(X(I2)-X(1))                                  COSAL   2028
      IK=0                                                      COSAL   2029
      DO 100 I=1,M                                              COSAL   2030
      IF(I.EQ.3)GO TO 100                                       COSAL   2031
      IK=IK+1                                                   COSAL   2032
      JJ=0                                                      COSAL   2033
      DO 110 J=1,M                                              COSAL   2034
      IF(J.EQ.3)GO TO 99                                        COSAL   2035
      JJ=JJ+1                                                   COSAL   2036
      JJJ=JJ+M-1                                                COSAL   2037
      FAC=BNDRY(IK,JJJ)*XO                                      COSAL   2038
      BB(I,J,1)=BNDRY(IK,JJ)-FAC                                COSAL   2039
      CC(I,J,1)=FAC                                             COSAL   2040
      GO TO 110                                                 COSAL   2041
 99   BB(I,J,1)=CC(I,J,1)=0.                                    COSAL   2042
 110  CONTINUE                                                  COSAL   2043
 100  CONTINUE                                                  COSAL   2044
                                                                COSAL   2045
      RETURN                                                    COSAL   2046
      END                                                       COSAL   2047
      SUBROUTINE ZMAP(I,X,G,FG,FF,XF,XF1,XF2,XB2,XC2)           COSAL   2048
C   ONLY GOOD FOR EQUAL GRID                                    COSAL   2049
      DIMENSION X(1)                                            COSAL   2050
      XX=G-X(I)                                                 COSAL   2051
      XC=XX**2*FG                                               COSAL   2052
      X1=XX**3*FF                                               COSAL   2053
      X2=X1*XX                                                  COSAL   2054
      III=I+1                                                   COSAL   2055
      IF(I.EQ.1)GO TO 10                                        COSAL   2056
      II=I-1                                                    COSAL   2057
      XINV=1./(X(III)-X(II))                                    COSAL   2058
      XF2=(X2/(X(III)-X(I))-X1)*XINV                            COSAL   2059
      XB2=(X2/(X(I)-X(II))+X1)*XINV                             COSAL   2060
      XC2=-XF2-XB2                                              COSAL   2061
      XF=XO*XINV                                                COSAL   2062
 10   XX=G-0.5*(X(I)+X(III))                                    COSAL   2063
      XO=XX**2*FG                                               COSAL   2064
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      XINV=1./(X(II1)-X(I))
      XF1=XO*XINV
      RETURN
      END
      SUBROUTINE GSET(ALPHA,BETA,OMEGA,M,N,A,IA,ID)
      REAL NU,MU1,NU2,LAM,LM1,MU
      COMPLEX IOTA
      DIMENSION U(101),U1(101),U2(101),W(101),W1(101),W2(101),T(101),
     1 T1(101),T2(101),NU(101),NU1(101),NU2(101)
      COMPLEX OMEGA,PSI
      COMPLEX A(M,M,1)
      COMPLEX B11,B12,B14,B21,B22,B23,B32,B41,B44,B45,B54,B55,
     1 C11,C12,C13,C14,C21,C22,C24,C31,C32,C33,C34,C42,C43,C44,
     2 C52,C54,C55
      COMMON /PROP/ XMACH,GAMA,RE,XPR,DB
      COMMON /DUMY/ U,U1,U2,W,W1,W2,T,T1,T2,NU,NU1,NU2
      COMMON /BCBC/ B12,B21,B23,C11,C13,C22,C31,C33,C34,C43,C44,C55
      I4=4
      I5=5
      ALBT=ALPHA*ALPHA+BETA*BETA
      LAM=(2.+DB)*2./3.
      CHI=LAM-2.
      LM1=LAM-1.
      GM1=GAMA-1.
      SIG=XPR
      IOTA=(0.,1.)
      DO 100 LL=1,N
      L=N-LL+1
      DO 10 I=1,M
      DO 10 J=1,M
      A(I,J,L)= (0.,0.)
   10 CONTINUE
      IF(ID.EQ.1)GO TO 105
      AN1=NU1(L)/NU(L)
      MU=NU(L)
      AU1=ALPHA*U1(L)+BETA*W1(L)
      AW1=ALPHA*W1(L)-BETA*U1(L)
      IF(IA.EQ.1)GO TO 1000
      B11=AN1*T1(L)
      B12=IOTA*LM1*ALBT
      B21=IOTA*LM1/LAM
      B22=B11
      B23=-RE/(MU*LAM)
      B32=1.
      A(1,1,L)=B11
      A(1,2,L)=B12
      A(2,1,L)=B21
      A(2,2,L)=B22
```

```
      A(2,3,L)=B23
      A(3,2,L)=B32
      B14=AN1*AU1
      B41=2.*GM1*XMACH*SIG*AU1/ALBT
      B44=2.*B11
      A(1,I4,L)=B14
      A(I4,1,L)=B41
      A(I4,I4,L)=B44
      IF(M.EQ.4)GO TO 100
      B45=2.*GM1*XMACH*SIG*AW1/ALBT
      B54=AN1*AW1
      B55=B11
      A(I4,I5,L)=B45
      A(I5,I4,L)=B54
      A(I5,I5,L)=B55
      GO TO 100
 1000 CONTINUE
      PSI=IOTA*(ALPHA*U(L)+BETA*W(L)-OMEGA)
      AN2=NU2(L)/NU(L)
      AU2=ALPHA*U2(L)+BETA*W2(L)
      AW2=ALPHA*W2(L)-BETA*U2(L)
      TM=1./(NU(L)*T(L))
      C11=-(RE*PSI*TM+LAM*ALBT)
      C12=-(RE*AU1*TM-IOTA*AN1*T1(L)*ALBT)
      C13=-IOTA*RE*ALBT/MU
      C21=IOTA*CHI*AN1*T1(L)/LAM
      C22=-(RE*PSI*TM+ALBT)/LAM
      C31=IOTA
      C32=-T1(L)/T(L)
      C33=GAMA*XMACH*PSI
      A(1,1,L)=C11
      A(1,2,L)=C12
      A(1,3,L)=C13
      A(2,1,L)=C21
      A(2,2,L)=C22
      A(3,1,L)=C31
      A(3,2,L)=C32
      A(3,3,L)=C33
      C14=AU1*AN2*T1(L)+AU2*AN1
      C24=IOTA*AN1*AU1/LAM
      C34=-PSI/T(L)
      C42=-(RE*T1(L)*TM-2.*IOTA*GM1*XMACH*AU1)*SIG
      C43=RE*SIG*GM1*XMACH*PSI/MU
      C44=-(RE*SIG*PSI*TM+ALBT-GM1*SIG*XMACH*AN1*(U1(L)**2+W1(L)**2)
     1 -AN2*T1(L)**2-AN1*T2(L))
      A(1,I4,L)=C14
      A(2,I4,L)=C24
      A(3,I4,L)=C34
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      A(I4,2,L)=C42
      A(I4,3,L)=C43
      A(I4,I4,L)=C44
      IF(M.EQ.4)GO TO 100
      C52=-RE*AW1*TM
      C54=AN2*T1(L)*AW1+AN1*AW2
      C55=-(PE*PSI*TM+ALBT)
      A(I5,2,L)=C52
      A(I5,I4,L)=C54
      A(I5,I5,L)=C55
      GO TO 100
105   CONTINUE
      IF(IA.EQ.0)GO TO 100
      PSI=-IOTA
      MU=NU(L)
      TM=1./(NU(L)*T(L))
      C11=-RE*PSI*TM
      C22=C11/LAM
      C33=GAMA*XMACH*PSI
      C13=C31=B12=B21=B23=0.
      A(1,1,L)=C11
      A(2,2,L)=C22
      A(3,3,L)=C33
      C34=-PSI/T(L)
      C43=PE*SIG*GM1*XMACH*PSI/MU
      C44=C11*SIG
      A(3,I4,L)=C34
      A(I4,3,L)=C43
      A(I4,I4,L)=C44
      IF(M.EQ.4)GO TO 100
      C55=C11
      A(I5,I5,L)=C55
100   CONTINUE
      RETURN
      END
      SUBROUTINE BOUNDRY(IR,IC,M)
      COMPLEX ROOT(8),PSI(8,8),BB(8,8),BNDRY(4,8),P,Q,R
      COMPLEX A,B,C,D,E,F,G,H,S,B12,B21,B23,C11,C13,C22,C31,
     1 C33,C34,C43,C44,C55
      DIMENSION IR(8,1),IC(8,1)
      COMMON /BCBC/ B12,B21,B23,C11,C13,C22,C31,C33,C34,C43,C44,C55
      COMMON /BDRY/ BNDRY
      COMMON /DUMWRK/ DUMMY(200),ROOT,PSI,BB,A,B,C,D,E,F,G,H,S,P,Q,R
      I5=5
      I4=4
      MM1=M-1
      IM=2*MM1
      IMM2=IM-2
```

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      A=B12-C13/C33                                              COSAL    2209
      H=1./(1.-B23/C33)                                          COSAL    2210
      B=(B21-B23*C31/C33)*H                                      COSAL    2211
      E=C11-C13*C31/C33                                          COSAL    2212
      G=C22*H                                                    COSAL    2213
      C=-B23*C34*H/C33                                           COSAL    2214
      D=-C43/C33                                                 COSAL    2215
      F=-C13*C34/C33                                             COSAL    2216
      H=-C43*C31/C33                                             COSAL    2217
      S=C44-C43*C34/C33                                          COSAL    2218
      P=G+E+S-A*B-C*D                                            COSAL    2219
      Q=S*E-H*F+E*G+S*G-A*B*S+B*D*F-C*E*D+A*H*C                  COSAL    2220
      R=S*E*G-G*H*F                                              COSAL    2221
      CALL ROOTS(ROOT,P,Q,R)                                     COSAL    2222
      IF(M.EQ.4)GO TO 105                                        COSAL    2223
      ROOT(7)=CSQRT(-C55)                                        COSAL    2224
      ROOT(8)=-ROOT(7)                                           COSAL    2225
105     CONTINUE                                                 COSAL    2226
      DO 888 I=1,IM                                              COSAL    2227
      DO 888 J=1,IM                                              COSAL    2228
888   PSI(I,J)=0.                                                COSAL    2229
      DO 3 J=1,6                                                 COSAL    2230
      PSI(1,J)=1.                                                COSAL    2231
      PSI(3,J)=(D*ROOT(J)**2+E*D-A*H)/(A*S-D*F+A*ROOT(J)**2)     COSAL    2232
       PSI(2,J)=-(ROOT(J)**2+E+F*PSI(3,J))/(A*ROOT(J))           COSAL    2233
3      CONTINUE                                                  COSAL    2234
      IF(M.NE.5)GO TO 121                                        COSAL    2235
      PSI(4,7)=1.                                                COSAL    2236
      PSI(4,8)=1.                                                COSAL    2237
121   CONTINUE                                                   COSAL    2238
      II=MM1                                                     COSAL    2239
      DO 51 I=1,MM1                                              COSAL    2240
      II=II+1                                                    COSAL    2241
      DO 51 J=1,IM                                               COSAL    2242
      PSI(II,J)=ROOT(J)*PSI(I,J)                                 COSAL    2243
51    CONTINUE                                                   COSAL    2244
      CC1=1.E-14                                                 COSAL    2245
      DO 26 I=1,IM                                               COSAL    2246
      DO 26 J=1,IM                                               COSAL    2247
      RPSI=REAL(PSI(I,J))                                        COSAL    2248
      APSI=AIMAG(PSI(I,J))                                       COSAL    2249
      IF(RPSI.LT.CC1)PSI(I,J)=CMPLX(CC1,APSI)                    COSAL    2250
26    CONTINUE                                                   COSAL    2251
      CALL LU(PSI,IM,8,IR,IC)                                    COSAL    2252
      DO 6 I=1,IM                                                COSAL    2253
      DO 6 J=1,IM                                                COSAL    2254
      BB(I,J)=0.                                                 COSAL    2255
      IF(I.EQ.J)BB(I,J)=1.                                       COSAL    2256
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      6 CONTINUE                                                COSAL 2257
        CALL SOLVE(BB,PSI,IM,IM,8,IR,IC)                        COSAL 2258
        K=0                                                     COSAL 2259
 89     FORMAT(1X,4G20.13)                                      COSAL 2260
        DO 16 I=1,IM                                            COSAL 2261
        IF(REAL(ROOT(I)).LE.0.)GO TO 16                         COSAL 2262
        K=K+1                                                   COSAL 2263
        DO 17 J=1,IM                                            COSAL 2264
     17 BNDRY(K,J)=BB(I,J)                                      COSAL 2265
     16 CONTINUE                                                COSAL 2266
        RETURN                                                  COSAL 2267
        END                                                     COSAL 2268
        SUBROUTINE ROOTS(Y,P,Q,R)                               COSAL 2269
C     FINDS ROOTS OF Y**6+P*Y**4+Q*Y**2+R=0                     COSAL 2270
        COMPLEX Y(6),P,Q,R,A,B,AA,W1,W2                         COSAL 2271
        DATA   X/.3333333333333/,S03/1.732050807569/            COSAL 2272
        DATA   PI/3.14159265359/                                COSAL 2273
        A=(3.*Q-P*P)*X                                          COSAL 2274
        B=(2.*P*P*P-9.*P*Q+27.*R)/27.                           COSAL 2275
        AA=CSQRT(B*B/4.+A*A*A/27.)                              COSAL 2276
        AA=(-B/2.+AA)                                           COSAL 2277
        B=A*X                                                   COSAL 2278
        A=CABS(AA)**X                                           COSAL 2279
        AIAA=AIMAG(AA)                                          COSAL 2280
        REAA=REAL(AA)                                           COSAL 2281
        IF(REAA.NE.0.)GO TO 1                                   COSAL 2282
        IF(AIAA.GT.0.)TA=0.5*PI                                 COSAL 2283
        IF(AIAA.LT.0.)TA=1.5*PI                                 COSAL 2284
        GO TO 20                                                COSAL 2285
  1     THETA=ATAN(AIAA/REAA)                                   COSAL 2286
        IF(REAA.LT.0.)GO TO 10                                  COSAL 2287
        IF(AIAA.GE.0.)TA=THETA                                  COSAL 2288
        IF(AIAA.LT.0.)TA=THETA+2.*PI                            COSAL 2289
         GO TO 20                                               COSAL 2290
 10      TA=THETA+PI                                            COSAL 2291
 20      CONTINUE                                               COSAL 2292
        TA=TA*X                                                 COSAL 2293
        AA=A*CMPLX(COS(TA),SIN(TA))                             COSAL 2294
        W1=CMPLX(-1.,S03)*0.5                                   COSAL 2295
        W2=CMPLX(-1.,-S03)*0.5                                  COSAL 2296
        P=P*X                                                   COSAL 2297
        Y(1)=AA-B/AA-P                                          COSAL 2298
        Y(3)=W1*AA-B/(W1*AA)-P                                  COSAL 2299
        Y(5)=W2*AA-B/(W2*AA)-P                                  COSAL 2300
        Y(1)=CSQRT(Y(1))                                        COSAL 2301
        Y(2)=-Y(1)                                              COSAL 2302
        Y(3)=CSQRT(Y(3))                                        COSAL 2303
        Y(4)=-Y(3)                                              COSAL 2304
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      Y(5)=CSQRT(Y(5))
      Y(6)=-Y(5)
      RETURN
      END
      SUBROUTINE OLDK(ALPHA,BETA,OMEGA,M,N,A,IA,FA,FB,KB)
      REAL NU,NU1,NU2,LAM,LM1,MU,KB
      COMPLEX IOTA
      DIMENSION U(101),U1(101),U2(101),W(101),W1(101),W2(101),T(101),
     1 T1(101),T2(101),NU(101),NU1(101),NU2(101)
      COMPLEX OMEGA,PSI
      COMPLEX A(M,M,1)
      COMPLEX B11,B12,B14,B21,B22,B23,B32,B41,B44,B45,B54,B55,
     1 C11,C12,C13,C14,C21,C22,C24,C31,C32,C33,C34,C42,C43,C44,
     2 C52,C54,C55
      COMMON /PROP/ XMACH,GAMA,RE,XPR,DB
      COMMON /DUMY/ U,U1,U2,W,W1,W2,T,T1,T2,NU,NU1,NU2
      I4=4
      I5=5
      TKB=2.*KB
      ALPHA2=ALPHA*ALPHA
      BETA2=BETA*BETA
      ALBT=ALPHA2+BETA2
      LAM=(2.+DB)*2./3.
      CHI=LAM-2.
      LM1=LAM-1.
      GM1=GAMA-1.
      SIG=XPR
      IOTA=(0.,1.)
      DO 100 LL=1,N
      L=N-LL+1
      DO 10 I=1,M
      DO 10 J=1,M
      A(I,J,L)= (0.,0.)
10      CONTINUE
      AN1=-U1(L)/NU(L)
      MU=NU(L)
      AU1=FA*U1(L)+FB*W1(L)
      AW1=FA*W1(L)-FB*U1(L)
      IF(IA.EQ.1)GO TO 1000
      B12=IOTA*LM1*TKB
      A(1,2,L)=B12
      B14=AN1*AU1
      B41=2.*GM1*XMACH*SIG*(AU1-(ALPHA*U1(L)+BETA*W1(L))*KB/ALBT)/ALBT
      A(1,I4,L)=B14
      A(I4,1,L)=B41
      IF(M.EQ.4)GO TO 100
      B45=2.*GM1*XMACH*SIG*(AW1-(ALPHA*W1(L)-BETA*U1(L))*KB/ALBT)/ALBT
      B54=AN1*AW1
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      A(I4,I5,L)=B45
      A(I5,I4,L)=B54
      GO TO 100
 1000 CONTINUE
      PSI=IOTA*(FA*U(L)+FB*W(L))
      AN2=NU2(L)/NU(L)
      AU2=FA*U2(L)+FB*W2(L)
      AW2=FA*W2(L)-FB*U2(L)
      TM=1./(NU(L)*T(L))
      C11=-(RE*PSI*TM+LAM*TKB)
      C12=-(RE*AU1*TM-IOTA*AN1*T1(L)*TKB)
      C13=-IOTA*RE*TKB/MU
      C22=-(RE*PSI*TM+TKB)/LAM
      C33=GAMA*XMACH*PSI
      A(1,1,L)=C11
      A(1,2,L)=C12
      A(1,3,L)=C13
      A(2,2,L)=C22
      A(3,3,L)=C33
      C14=AU1*AN2*T1(L)+AU2*AN1
      C24=IOTA*AN1*AU1/LAM
      C34=-PSI/T(L)
      C42=2.*IOTA*GM1*XMACH*AU1*SIG
      C43=RE*SIG*GM1*XMACH*PSI/MU
      C44=-(RE*SIG*PSI*TM+TKB)
      A(1,I4,L)=C14
      A(2,I4,L)=C24
      A(3,I4,L)=C34
      A(I4,2,L)=C42
      A(I4,3,L)=C43
      A(I4,I4,L)=C44
      IF(M.EQ.4)GO TO 100
      C52=-RE*AW1*TM
      C54=AN2*T1(L)*AW1+AN1*AW2
      C55=-(RE*PSI*TM+TKB)
      A(I5,2,L)=C52
      A(I5,I4,L)=C54
      A(I5,I5,L)=C55
  100 CONTINUE
      RETURN
      END
      SUBROUTINE GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORK,NDIM,M,NP1,IR,IC,
     1AL,BL,OMEGA,CSP)
      COMPLEX A(M,M,1),B(M,M,1),AA(M,M,1),BB(M,M,1),CC(M,M,1),
     1 AC(NDIM,1),EIGA(1),WORK(1)
C   WORK SHOULD BE DIMENSIONED 2*NDIM IN THE MAIN PROGRAM
      DIMENSION IR(M,1),IC(M,1),CSP(1),INDEX(10)
      COMPLEX OMEGA
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      COMMON /GLOBE/ ILOC                                               COSAL    2401
      COMMON /FUN/ JPASS                                                COSAL    2402
      COMMON /IGLOB/ IGLOB                                              COSAL    2403
      COMMON /PRINTS/ IPR1,IPR2,IPR3,IPR4,IPR5,IPR6,IPR7                COSAL    2404
      ILOC=1                                                            COSAL    2405
      M2=M*M                                                            COSAL    2406
      NM=NP1-1                                                          COSAL    2407
      NT1=NM*M                                                          COSAL    2408
      CALL FLOWMAP(NP1,CSP)                                             COSAL    2409
      OMEGA=(0.,0.)                                                     COSAL    2410
      CALL GSET(AL,BL,OMEGA,M,NP1,A,0,0)                                COSAL    2411
      CALL GSET(AL,BL,OMEGA,M,NP1,B,1,0)                                COSAL    2412
      CALL ABCSET(A,B,M,NP1,AA,BB,CC,0)                                 COSAL    2413
      CALL SETAC(AA,BB,CC,NM,M,NT1,NDIM,AC)                             COSAL    2414
      CALL GSET(AL,BL,OMEGA,M,NP1,AA,1,1)                               COSAL    2415
      CALL ABCSET(AA,AA,M,NP1,AA,BB,CC,1)                               COSAL    2416
      CALL BLKLU(AA,BB,CC,NM,M,M2,IR,IC,OMEGA)                          COSAL    2417
      DO 100 K=1,NT1                                                    COSAL    2418
      CALL BLKSOLV(AA,BB,CC,NM,M,M2,IR,IC,AC(1,K))                      COSAL    2419
  100 CONTINUE                                                          COSAL    2420
      CALL CMPXLR(AC,NT1,NDIM,EIGA,WORK,IER)                            COSAL    2421
      IF(IPR2.NE.1)GO TO 441                                            COSAL    2422
      WRITE(6,38)AL,BL                                                  COSAL    2423
      NT2=NT1-M+1                                                       COSAL    2424
      NTHF=NT2/2                                                        COSAL    2425
      NTHF1=(NT2+1)/2                                                   COSAL    2426
      IEOD=0                                                            COSAL    2427
      IF(NTHF1.GT.NTHF)IEOD=1                                           COSAL    2428
      NTHF=NTHF+IEOD                                                    COSAL    2429
      DO 439 I=1,NTHF                                                   COSAL    2430
      IF(IEOD.EQ.1.AND.I.EQ.NTHF)GO TO 404                              COSAL    2431
      II=I+NTHF                                                         COSAL    2432
      WRITE(6,564)I,EIGA(I),II,EIGA(II)                                 COSAL    2433
      GO TO 439                                                         COSAL    2434
  404     WRITE(6,565)I,EIGA(I)                                         COSAL    2435
  439  CONTINUE                                                         COSAL    2436
  441  CONTINUE                                                         COSAL    2437
      DO 440 I=1,NT1                                                    COSAL    2438
  440 EIGA(I)=-EIGA(I)                                                  COSAL    2439
      CALL MAXEIG(EIGA,OMEGA,NT1,MM,INDEX)                              COSAL    2440
   38  FORMAT(///,5X,*NEGATIVE OF GLOBAL EIGENVALUE SPECTRUM PRINTED FORCOSAL    2441
     1:*,//,10X,*ALPHA= *,G12.5,5X,*BETA= *,G12.5,//)                   COSAL    2442
  564 FORMAT(5X,I5,2G20.10,5X,I5,2G20.10)                               COSAL    2443
  565 FORMAT(5X,I5,2G20.10)                                             COSAL    2444
      RETURN                                                            COSAL    2445
      END                                                               COSAL    2446
      SUBROUTINE SETAC(A,B,C,N,M,NT1,NDIM,AC)                           COSAL    2447
      COMPLEX A(M,M,1),B(M,M,1),C(M,M,1),AC(NDIM,1)                     COSAL    2448
```

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```
      DO 1 I=1,NT1                                                      COSAL
      DO 1 J=1,NT1                                                      COSAL
1     AC(I,J)=0.                                                        COSAL
      DO 10 J=1,N                                                       COSAL
      JM1=J-1                                                           COSAL
      JM2=J-2                                                           COSAL
      DO  10 I=1,M                                                      COSAL
      DO  10 L=1,M                                                      COSAL
      IF(J.NE.1)AC(I+JM1*M,L+JM2*M)=A(I,L,J)                           COSAL
      AC(I+JM1*M,L+JM1*M)=B(I,L,J)                                      COSAL
      IF(J.NE.N)AC(I+JM1*M,L+J*M)=C(I,L,J)                             COSAL
10    CONTINUE                                                          COSAL
      RETURN                                                            COSAL
      END                                                               COSAL
      SUBROUTINE BSLINT (KFCN,KORD,X,F,MX,U,G,IU)                       COSAL
      DIMENSION X(1), U(1), G(1), F(1,1)                                COSAL
      COMMON /BSL1CM/ LOG,KERR,L,M,N,P,XM,XP,FM,FP,D2FM,D2FP,EPS,ONE    COSAL
      DATA LOG,KERR,L,M,N/6,0,1,1,1/                                    COSAL
      DATA D2FM,D2FP,EPS,ONE/0.,0.,1.E-7,1.0000001/                     COSAL
      P2(DX,FM1,F0,FP1)=(FP1-2.*F0+FM1)/DX**2                           COSAL
      V2(DXM,DXP,FM1,F0,FP1)=(2.*(FP1-F0)/DXP-2.*(F0-FM1)/DXM)/(DXM+DXP)COSAL
      BSL(P,DX,F0,D2F0,F1,D2F1)=F0+P*(F1-F0)-P*(1.-P)*DX**2*(C2*(D2F0+D2COSAL
     1F1)+(P-.5)*C3*(D2F1-D2F0))                                        COSAL
      D1P(P,DX,F0,D2F0,F1,D2F1)=(F1-F0)/DX+DX*((2.*P-1.)*C2*(D2F0+D2F1)-COSAL
     1(3.*P*(1.-P)-.5)*C3*(D2F1-D2F0))                                  COSAL
      D2B(P,DX,F0,D2F0,F1,D2F1)=2.*C2*(D2F0+D2F1)+(6.*P-3.)*C3*(D2F1-D2FCOSAL
     10)                                                                COSAL
      II2=2                                                             COSAL
      KERR=0                                                            COSAL
      IMX=MAX0(1,IABS(IU))                                              COSAL
      IF (KORD.LT.0) GO TO 6                                            COSAL
      IFCN=IABS(KFCN)                                                   COSAL
      IORD=IABS(KORD)                                                   COSAL
      MMX=IABS(MX)                                                      COSAL
      IF (MMX.LT.4) IORD=1                                              COSAL
      MM1=MMX-1                                                         COSAL
      IF (M.GT.MM1) M=MM1/2+1                                           COSAL
      DX=1.                                                             COSAL
      INDX=ISIGN(1,MX)+ISIGN(1,IU)                                      COSAL
      IF (INDX) 3,1,2                                                   COSAL
1     IF (IU.LT.0) INDX=2                                               COSAL
2     DX=(X(II2)-X(1))                                                  COSAL
      S1X=SIGN(1.,DX)                                                   COSAL
3     CONTINUE                                                          COSAL
      RDX=1./DX                                                         COSAL
      C2=0.                                                             COSAL
      C3=0.                                                             COSAL
      IF (IORD-2) 6,5,4                                                 COSAL
```

```
4       C3=1./6.
5       C2=.25
6       CONTINUE
        I=0
7       CONTINUE
        I=I+1
        IF (I.GT.IMX) GO TO 35
        IF (INDX.GE.0) UI=U(I)
        IF (INDX) 8,9,12
8       CONTINUE
        XM=UI
        IF (IMX.GT.1) XM=FLOAT(I-1)/FLOAT(IMX-1)*FLOAT(MM1)+1.
        P=XM
        XM=XM-FLOAT(INT(XM)/MMX)
        XP=XM+1.
        M=XM+EPS
        P=P-FLOAT(M)
        GO TO 10
9       CONTINUE
        M=(UI-X(1))*RDX+ONE
        M=M-M/MMX
        XP=X(1)+FLOAT(M)*DX
        XM=XP-DX
        P=(UI-XM)*RDX
10      CONTINUE
        IF (M.LT.1.OR.M.GT.MM1) GO TO 36
        GI=M
        IF (IORD.LE.0) GO TO 11
        XM1=XM-DX
        XP1=XP+DX
        IF (P*(1.-P).GT.EPS) GO TO 20
        IF (IFCN.NE.0) GO TO 20
        M=FLOAT(M)+(P+.5)
        N=L*(M-1)+1
        GI=F(N,1)
11      CONTINUE
        G(I)=GI
        GO TO 7
12      CONTINUE
        N=0
        M=MIN0(M,MM1)
        M1=1
        M2=MMX
13      CONTINUE
        IF (S1X*(X(M+1)-X(M)).LE.0.) GO TO 37
        IF (S1X*(UI-X(M))) 14,18,16
14      CONTINUE
        IF (M.LE.1) GO TO 36
```

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```
      M=M-1                                                             COSAL  2545
      IF (S1X*(UI-X(M))) 15,18,18                                       COSAL  2546
15    M2=M                                                              COSAL  2547
      IF (N.NE.0) M=(M1+M)/2                                            COSAL  2548
      N=1                                                               COSAL  2549
      GO TO 13                                                          COSAL  2550
16    CONTINUE                                                          COSAL  2551
      IF (S1X*(UI-X(M+1))) 18,18,17                                     COSAL  2552
17    M=M+1                                                             COSAL  2553
      IF (M.GE.MMX) GO TO 36                                            COSAL  2554
      M1=M                                                              COSAL  2555
      IF (N.NE.0) M=(M+M2)/2                                            COSAL  2556
      N=1                                                               COSAL  2557
      GO TO 13                                                          COSAL  2558
18    CONTINUE                                                          COSAL  2559
      M=MIN0(M,MM1)                                                     COSAL  2560
      XM=X(M)                                                           COSAL  2561
      XP=X(M+1)                                                         COSAL  2562
      GI=M                                                              COSAL  2563
      IF (IORD.LE.0) GO TO 19                                           COSAL  2564
      DX=XP-XM                                                          COSAL  2565
      RDX=1./DX                                                         COSAL  2566
      P=(UI-XM)*RDX                                                     COSAL  2567
      IF (M.GT.1) XM1=X(M-1)                                            COSAL  2568
      IF (M.LT.MM1) XP1=X(M+2)                                          COSAL  2569
      IF (P*(1.-P).GT.EPS) GO TO 20                                     COSAL  2570
      IF (IFCN.NE.0) GO TO 20                                           COSAL  2571
      M=FLOAT(M)+(P+.5)                                                 COSAL  2572
      N=L*(M-1)+1                                                       COSAL  2573
      GI=F(N,1)                                                         COSAL  2574
19    CONTINUE                                                          COSAL  2575
      G(I)=GI                                                           COSAL  2576
      GO TO 7                                                           COSAL  2577
20    CONTINUE                                                          COSAL  2578
      N=L*(M-1)+1                                                       COSAL  2579
      LM1=1-L                                                           COSAL  2580
      FM=F(N,1)                                                         COSAL  2581
      FP=F(N,L+1)                                                       COSAL  2582
      IF (M.GT.1) FM1=F(N,LM1)                                          COSAL  2583
      IF (M.LT.MM1) FP1=F(N,2*L+1)                                      COSAL  2584
      IF (IORD-1) 7,30,21                                               COSAL  2585
21    CONTINUE                                                          COSAL  2586
      IF (ISIGN(M-1,INDX-1)) 22,23,24                                   COSAL  2587
22    D2FM=D2(DX,FM1,FM,FP)                                             COSAL  2588
      GO TO 25                                                          COSAL  2589
23    LP2=3*L+1                                                         COSAL  2590
      XP2=XP1+DX                                                        COSAL  2591
      IF (INDX.GT.0) XP2=X(M+3)                                         COSAL  2592
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```
      FP2=F(N,LP2)
      D2FM=V2(DX,XP1-XP,FM,FP,FP1)
      D2FM=D2FM+(XP1-XP)/(XP2-XP1)*(D2FM-V2(XP1-XP,XP2-XP1,FP,FP1,FP2))
      GO TO 25
24    D2FM=V2(XM-XM1,DX,FM1,FM,FP)
25    CONTINUE
      IF (ISIGN(MM1-M,INDX-1)) 26,27,28
26    D2FP=B2(DX,FM,FP,FP1)
      GO TO 29
27    LM2=1-2*L
      XM2=XM1-DX
      IF (INDX.GT.0) XM2=X(M-2)
      FM2=F(N,LM2)
      D2FP=V2(XM-XM1,DX,FM1,FM,FP)
      D2FP=D2FP+(XM-XM1)/(XM1-XM2)*(D2FP-V2(XM1-XM2,XM-XM1,FM2,FM1,FM))
      GO TO 29
28    D2FP=V2(DX,XP1-XP,FM,FP,FP1)
29    CONTINUE
30    CONTINUE
      IF (IFCN-1) 33,31,32
31    CONTINUE
      GI=D1B(P,DX,FM,D2FM,FP,D2FP)
      GO TO 34
32    CONTINUE
      GI=D2B(P,DX,FM,D2FM,FP,D2FP)
      GO TO 34
33    CONTINUE
      GI=BSI(P,DX,FM,D2FM,FP,D2FP)
34    CONTINUE
      G(I)=GI
      GO TO 7
35    CONTINUE
      L=1
      RETURN
36    CONTINUE
      KERR=I
      GO TO 35
37    CONTINUE
      KERR=-M
      GO TO 35
      END
      SUBROUTINE STARTUP (ALPHA,BETA,REY,NC,EIGA,A,B,AA,BB,CC,AC,WORKC,
     1 NDIM,M,MG,NG,UU,UWRK,VV,VWRK,CSP,WORK,IR,IC,FREQ,XLAM,VA,VB,
     2 XLAM1,VA1,VB1,EPS,ALPHA1,BETA1,ALPHA2,BETA2)
      COMPLEX EIGA(1),WORKC(1),VA,VB,VA1,VB1
      DIMENSION WORK(1),IR(M,1),IC(M,1),CSP(1)
      COMPLEX AC(NDIM,1),A(M,M,1),B(M,M,1),AA(M,M,1),BB(M,M,1),
     1 CC(M,M,1),UU(M,1),UWRK(M,1),VV(M,1),VWRK(M,1),XLAM,XLAM1
```

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```
      COMMON /FUN/ JPASS
      COMMON /PRINTS/ IPR1,IPR2,IPR3,IPR4,IPR5,IPR6,IPR7
      COMMON /IGLOB/ IGLOB
      ITER=0
C     IF ALPHA=0 AND BETA=0 MAKE INITIAL GUESS
      IF (ABS(ALPHA).GT.1.E-5.OR.ABS(BETA).GT.1.E-5) GO TO 1
      ALPHA=-.2
      BETA=.4
    1 IF (JPASS.NE.0) GO TO 2
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA,BETA,XLAM,CSP)
      IPASS=0
    2 CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
     1 ALPHA,BETA,XLAM,VA,VB,CSP,WORK)
      IF (IGLOB.EQ.3) JPASS=0
      IF (IPR7.EQ.0) GO TO 3
      WRITE (6,9) ITER,ALPHA,BETA,XLAM,VA,VB
    3 CONTINUE
      RVA=REAL(VA)
      RVB=REAL(VB)
      AVA=AIMAG(VA)
      AVB=AIMAG(VB)
      ALPHA1=RVA*(FREQ-REAL(XLAM))
      BETA1=RVB*(FREQ-REAL(XLAM))
      SPD=RVA**2+RVB**2
      ALPHA1=ALPHA1/SPD+ALPHA
      BETA1=BETA1/SPD+BETA
      IF ((ABS(ALPHA-ALPHA1)+ABS(BETA-BETA1)).LT.EPS) GO TO 4
      XLAM=XLAM+VA*(ALPHA1-ALPHA)+VB*(BETA1-BETA)
      ITER=ITER+1
      ALPHA=ALPHA1
      BETA=BETA1
      IF (ITER.GT.10) GO TO 4
      GO TO 1
    4 WAVE=ALPHA**2+BETA**2
      IF (ITER.GT.10) WRITE (6,10)
      IF (ABS(RVA).GT.ABS(RVB)) GO TO 5
      S=.02*SQRT(WAVE)/RVB
      GO TO 6
    5 S=.02*SQRT(WAVE)/RVA
    6 ALPHA1=ALPHA-S*RVB
      BETA1=BETA+S*RVA
      XLAM1=XLAM
      IF (JPASS.NE.0) GO TO 7
      CALL GLOBAL(A,B,AA,BB,CC,AC,EIGA,WORKC,NDIM,MG,NG,IR,IC,
     1 ALPHA1,BETA1,XLAM1,CSP)
      IPASS=0
    7 CALL LOCAL(A,B,AA,BB,CC,UU,UWRK,VV,VWRK,M,NC,IR,IC,
```

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```
      1 ALPHA1,BETA1,XLAM1,VA1,VB1,CSP,WORK)
       IF (IGLOB.EQ.3) JPASS=0
       IF (IPR7.EQ.0) GO TO 8
       WRITE (6,11)
       WRITE (6,9) ITER,ALPHA1,BETA1,XLAM1,VA1,VB1
8      CONTINUE
       RVA=REAL(VA1)
       RVB=REAL(VB1)
       AVA=AIMAG(VA1)
       AVB=AIMAG(VB1)
       ALPHA2=RVA*(FREQ-REAL(XLAM1))
       BETA2=RVB*(FREQ-REAL(XLAM1))
       SPD=RVA**2+RVB**2
       ALPHA2=ALPHA2/SPD+ALPHA1
       BETA2=BETA2/SPD+BETA1
       RETURN
C
C
9      FORMAT (/1X,25HSTARTUP ITERATION ITER = ,I5/1X,8HALPHA = ,F10.6,5X
      1,7HBETA = ,F10.6,5X,8HOMEGA = ,2E20.13,/,1X,5HVA = ,2E20.13,10X,5H
      2VB = ,2E20.13/)
10     FORMAT (/1X,77HWARNING--STARTUP ROUTINE HAS EXCEEDED 10 ITERATIONS
      1-- CHECK STARTUP RESULTS--/)
11     FORMAT (1X,20HSECOND STARTUP POINT)
       END
       SUBROUTINE OPTIMAL (FREQ,ALPHA1,BETA1,XL1,VA1,VB1,ALPHA2,BETA2,XL2
      1,VA2,VB2,A,B)
       COMMON /OPTSTS/ G1,G2,H,HN
       COMPLEX VA1,VB1,VA2,VB2,XL1,XL2
      XX=SQRT(REAL(VA1)**2+REAL(VB1)**2)
      XA1=REAL(VA1)/XX
      XB1=REAL(VB1)/XX
      XX=SQRT(REAL(VA2)**2+REAL(VB2)**2)
      XA2=REAL(VA2)/XX
      XB2=REAL(VB2)/XX
      G1=XB1*AIMAG(VA1)-XA1*AIMAG(VB1)
      G2=XB2*AIMAG(VA2)-XA2*AIMAG(VB2)
      H=(ALPHA2-ALPHA1)*XB2-XA2*(BETA2-BETA1)
      HN=(ALPHA2-ALPHA1)*XA2+(BETA2-BETA1)*XB2
      GAM=-G1/(G2-G1)
1     GAM=GAM-1
       IF (GAM*H*G2.LT.0) GAM=2.*G2*H/SQRT((AIMAG(VA2)**2+AIMAG(VB2)**2)*
      1H**2)
       DA=XB2*GAM*H+(FREQ-REAL(XL2))*XA2/XX
       DB=-XA2*GAM*H+(FREQ-REAL(XL2))*XB2/XX
       A=ALPHA2+DA
       B=BETA2+DB
       RETURN
```

```
      END
      SUBROUTINE LU (A,N,NDIM,IR,IC)
C     THIS ROUTINE OPTIMIZED FOR CDC CYBER 175 AND CDC 7600
C     PROGRAM TO PERFORM FULLY PIVOTED LU DECOMPOSITION OF GENERAL
C     COMPLEX ARRAY A
C
      COMPLEX A(NDIM,1),B,C
      DIMENSION IR(1), IC(1)
      COMMON /LU1/ XMAX,B,NPRI,M,ICT1,ICT2,K1
      NPRI=N
      ICT1=2*NDIM
      DO 1 I=1,N
      IR(I)=I
    1 IC(I)=I
      K=1
      L=K
      M=K
      XMAX=ABS(REAL(A(K,K)))+ABS(AIMAG(A(K,K)))
      DO 2 I=K,N
      DO 2 J=K,N
      Y=ABS(REAL(A(I,J)))+ABS(AIMAG(A(I,J)))
      IF (XMAX.GE.Y) GO TO 2
      XMAX=Y
      L=I
      M=J
    2 CONTINUE
      DO 9 K=1,N
      IRL=IR(L)
      IR(L)=IR(K)
      IR(K)=IRL
      ICM=IC(M)
      IC(M)=IC(K)
      IC(K)=ICM
      IF (L.EQ.K) GO TO 4
      DO 3 J=1,N
      B=A(K,J)
      A(K,J)=A(L,J)
    3 A(L,J)=B
    4 IF (M.EQ.K) GO TO 6
      DO 5 I=1,N
      B=A(I,K)
      A(I,K)=A(I,M)
    5 A(I,M)=B
    6 C=1./A(K,K)
      A(K,K)=C
      IF (K.EQ.N) GO TO 9
      K1=K+1
      XMAX=ABS(REAL(A(K1,K1)))+ABS(AIMAG(A(K1,K1)))
```

C-3

```
      L=K1
      M=K1
      DO 7 I=K1,N
7     A(I,K)=C*A(I,K)
      DO 8 I=K1,N
      B=A(I,K)
      XMAXO=XMAX
      ICT2=(I-K)*2
      CALL OPT (A(K,K1),A(I,K1))
      IF (XMAX.NE.XMAXO) L=I
8     CONTINUE
9     CONTINUE
      RETURN
      END
          IDENT     OPT
          ENTRY     OPT
          USE       /LU1/
*                   THIS ROUTINE OPTIMIZED FOR CDC CYBER 175
*                   AND CDC 7600 COMPUTERS
XMAX      BSS       1
B         BSS       2
N         BSS       1
M         BSS       1
ICT1      BSS       1
ICT2      BSS       1
K1        BSS       1
          USE       *
OPT       DATA      0
          SX7       A1
          SB1       1
          SA3       XMAX
          SA1       B
          SA2       B1+B
          SA4       N
          SA5       M
          BX0       X3
          SA3       ICT1
          SB4       X4
          SA4       ICT2
          SB5       X5
          SA5       K1
          SB7       X3
          SB6       X4
          SB3       X5
          SB3       B3-B1
          SB2       60
          SA4       X7
          SA3       X4
```

```
          SA5       A4+B1
          SA5       X5
          SA4       A3+B1
L         FX6       X3*X1
          BX7       X5
          SA5       A5+B1
          FX3       X3*X2
          SB3       B3+B1
          FX6       X7-X6
          FX7       X4*X2
          FX4       X4*X1
          NX6       X6
          FX5       X5-X3
          FX6       X6+X7
          SA3       A3+B7
          FX7       X5-X4
          AX4       X6,B2
          AX5       X7,B2
          BX4       X6-X4
          BX5       X7-X5
          NX6       X6
          FX4       X4+X5
          SA5       A3+B6
          NX7       X7
          SA6       A5-B7
          FX6       X0-X4
          SA7       A6+B1
          BX7       X4
          SA4       A3+B1
          PL        X6,SKIP
          BX0       X7
          SB5       B3
SKIP      LT        B3,B4,L
          SX6       B5
          SA6       K
          BX7       X0
          SA7       XMAX
          EQ        OPT
          END
      SUBROUTINE SOLVE (F,A,K,N,NDIM,IR,IC)
C
C     PROGRAM TO SOLVE K EQUATIONS AX = F (DIMENSIONED NDIM)
C     ASSUME PREVIOUS CALL TO ROUTINE LU HAS BEEN MADE
C
      COMMON /DUMWRK/ G
      COMPLEX A(NDIM,1),F(NDIM,1),G(100),B
      DIMENSION IR(1), IC(1)
      N1=N+1
```

```
      DO 7 KK=1,K
      DO 1 I=1,N
      IRI=IR(I)
    1 G(I)=F(IRI,KK)
      DO 3 I=2,N
      I1=I-1
      B=G(I)
      DO 2 J=1,I1
    2 B=B-A(I,J)*G(J)
    3 G(I)=B
      DO 5 IT=1,N
      I=N1-IT
      I1=I+1
      B=G(I)
      IF (I.EQ.N) GO TO 5
      DO 4 J=I1,N
    4 B=B-A(I,J)*G(J)
    5 G(I)=B*A(I,I)
      DO 6 I=1,N
      ICI=IC(I)
    6 F(ICI,KK)=G(I)
    7 CONTINUE
      RETURN
      END
      SUBROUTINE SOLVTRN (F,A,N,NDIM,IR,IC)
      COMMON /DUMWRK/ G
      COMPLEX A(NDIM,1),F(1),G(100),B
      DIMENSION IR(1), IC(1)
      N1=N+1
      DO 1 I=1,N
      ICI=IC(I)
    1 G(I)=F(ICI)
      G(1)=A(1,1)*G(1)
      DO 3 I=2,N
      I1=I-1
      B=G(I)
      DO 2 J=1,I1
    2 B=B-A(J,I)*G(J)
    3 G(I)=B*A(I,I)
      DO 5 IT=2,N
      I=N1-IT
      I1=I+1
      B=G(I)
      IF (I.EQ.N) GO TO 5
      DO 4 J=I1,N
    4 B=B-A(J,I)*G(J)
    5 G(I)=B
      DO 6 I=1,N
```

```
      IRI=IR(I)                                                          COSAL    2929
    6 F(IRI)=G(I)                                                        COSAL    2930
      RETURN                                                             COSAL    2931
      END                                                                COSAL    2932
      SUBROUTINE BALANCE (AR,AI,N,IA,K,L,D)                              COSAL    2933
      INTEGER            N,IA,K,L                                        COSAL    2934
      REAL               AR(IA,1),AI(IA,1),D(N)                          COSAL    2935
      INTEGER            J,M,I,IEXC,L1,JJ                                COSAL    2936
      REAL               RADIX,ZERO,ONE,PT95,B2,F,C,G,R,S,RRADIX,RB2     COSAL    2937
      LOGICAL            NOCONV                                          COSAL    2938
      DATA               RADIX/2.0/                                      COSAL    2939
      DATA               ZERO,ONE,PT95/0.0,1.0,0.95/                     COSAL    2940
      B2 = RADIX*RADIX                                                   COSAL    2941
      RRADIX = ONE/RADIX                                                 COSAL    2942
      RB2 = RRADIX*RRADIX                                                COSAL    2943
      K = 1                                                              COSAL    2944
      L = N                                                              COSAL    2945
      GO TO 30                                                           COSAL    2946
    5 D(M) = J                                                           COSAL    2947
      IF (J .EQ. M) GO TO 20                                             COSAL    2948
      DO 10 I = 1,L                                                      COSAL    2949
         F = AR(I,J)                                                     COSAL    2950
         AR(I,J) = AR(I,M)                                               COSAL    2951
         AR(I,M) = F                                                     COSAL    2952
         F = AI(I,J)                                                     COSAL    2953
         AI(I,J) = AI(I,M)                                               COSAL    2954
         AI(I,M) = F                                                     COSAL    2955
   10 CONTINUE                                                           COSAL    2956
      DO 15 I=K,N                                                        COSAL    2957
         F = AR(J,I)                                                     COSAL    2958
         AR(J,I) = AR(M,I)                                               COSAL    2959
         AR(M,I) = F                                                     COSAL    2960
         F = AI(J,I)                                                     COSAL    2961
         AI(J,I) = AI(M,I)                                               COSAL    2962
         AI(M,I) = F                                                     COSAL    2963
   15 CONTINUE                                                           COSAL    2964
   20 IF(IEXC.EQ.2)GO TO 45                                              COSAL    2965
      IF (L .EQ. 1) GO TO 115                                            COSAL    2966
      L = L-1                                                            COSAL    2967
   30 L1 = L+1                                                           COSAL    2968
      DO 40 JJ = 1,L                                                     COSAL    2969
         J = L1-JJ                                                       COSAL    2970
         DO 35 I = 1,L                                                   COSAL    2971
            IF (I .EQ. J) GO TO 35                                       COSAL    2972
            IF (AR(J,I) .NE. ZERO .OR. AI(J,I) .NE. ZERO) GO TO 40       COSAL    2973
   35    CONTINUE                                                        COSAL    2974
         M = L                                                           COSAL    2975
         IEXC = 1                                                        COSAL    2976
```

```
      GO TO 5
   40 CONTINUE
      GO TO 50
   45 K = K+1
   50 DO 60 J = K,L
         DO 55 I = K,L
            IF (I .EQ. J) GO TO 55
            IF (AR(I,J) .NE. ZERO .OR. AI(I,J) .NE. ZERO) GO TO 60
   55    CONTINUE
         M = K
         IEXC = 2
         GO TO 5
   60 CONTINUE
      DO 65 I = K,L
         D(I) = ONE
   65 CONTINUE
   70 NOCONV = .FALSE.
      DO 110 I = K,L
         C = ZERO
         R = ZERO
         DO 75 J = K,L
            IF (J .EQ. I) GO TO 75
            C = C+ABS(AR(J,I))+ABS(AI(J,I))
            R = R+ABS(AR(I,J))+ABS(AI(I,J))
   75    CONTINUE
         G = R*RRADIX
         F = ONE
         S = C+R
   80    IF (C .GE. G) GO TO 85
         F = F*RADIX
         C = C*B2
         GO TO 80
   85    G = R*RADIX
   90    IF (C .LT. G) GO TO 95
         F = F*RRADIX
         C = C*RB2
         GO TO 90
   95    IF ((C+R)/F .GE. PT95*S) GO TO 110
         G = ONE/F
         D(I) = D(I)*F
         NOCONV = .TRUE.
         DO 100 J = K,N
            AR(I,J) = AR(I,J)*G
            AI(I,J) = AI(I,J)*G
  100    CONTINUE
         DO 105 J = 1,L
            AR(J,I) = AR(J,I)*F
            AI(J,I) = AI(J,I)*F
```

```
105    CONTINUE                                                          COSAL    3025
110 CONTINUE                                                             COSAL    3026
    IF (NOCONV) GO TO 70                                                 COSAL    3027
115 RETURN                                                               COSAL    3028
    END                                                                  COSAL    3029
    SUBROUTINE HESSC (AR,AI,K,L,N,IA,ID)                                 COSAL    3030
    INTEGER             K,L,N,IA,ID(1)                                   COSAL    3031
    REAL                AR(IA,1),AI(IA,1)                                COSAL    3032
    INTEGER             LA,KP1,M,I,J,MM1,MP1                             COSAL    3033
    REAL                XR,XI,YR,YI,T1(2),T2(2),ZERO                     COSAL    3034
    COMPLEX             X,Y                                              COSAL    3035
    EQUIVALENCE         (X,T1(1)),(T1(1),XR),(T1(2),XI),(Y,T2(1)),       COSAL    3036
   1                    (T2(1),YR),(T2(2),YI)                            COSAL    3037
    DATA                ZERO/0.0/                                        COSAL    3038
    LA=L-1                                                               COSAL    3039
    KP1=K+1                                                              COSAL    3040
    IF (LA .LT. KP1) GO TO 45                                            COSAL    3041
    DO 40 M=KP1,LA                                                       COSAL    3042
       I=M                                                               COSAL    3043
       XR=ZERO                                                           COSAL    3044
       XI=ZERO                                                           COSAL    3045
       DO 5 J=M,L                                                        COSAL    3046
          IF (ABS(AR(J,M-1))+ABS(AI(J,M-1)) .LE. ABS(XR)+ABS(XI))        COSAL    3047
   1      GO TO 5                                                        COSAL    3048
          XR=AR(J,M-1)                                                   COSAL    3049
          XI=AI(J,M-1)                                                   COSAL    3050
          I=J                                                            COSAL    3051
 5     CONTINUE                                                          COSAL    3052
       ID(M)=I                                                           COSAL    3053
       IF (I .EQ. M) GO TO 20                                            COSAL    3054
       MM1=M-1                                                           COSAL    3055
       DO 10 J=MM1,N                                                     COSAL    3056
          YR=AR(I,J)                                                     COSAL    3057
          AR(I,J)=AR(M,J)                                                COSAL    3058
          AR(M,J)=YR                                                     COSAL    3059
          YI=AI(I,J)                                                     COSAL    3060
          AI(I,J)=AI(M,J)                                                COSAL    3061
          AI(M,J)=YI                                                     COSAL    3062
10     CONTINUE                                                          COSAL    3063
       DO 15 J=1,L                                                       COSAL    3064
          YR=AR(J,I)                                                     COSAL    3065
          AR(J,I)=AR(J,M)                                                COSAL    3066
          AR(J,M)=YR                                                     COSAL    3067
          YI=AI(J,I)                                                     COSAL    3068
          AI(J,I)=AI(J,M)                                                COSAL    3069
          AI(J,M)=YI                                                     COSAL    3070
15     CONTINUE                                                          COSAL    3071
20     IF (XR .EQ. ZERO .AND. XI .EQ. ZERO) GO TO 40                     COSAL    3072
```

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```
      MP1=M+1
      DO 35 I=MP1,L
         YR=AR(I,M-1)
         YI=AI(I,M-1)
         IF (YR .EQ. ZERO .AND. YI .EQ. ZERO) GO TO 35
         Y=Y/X
         AR(I,M-1)=YR
         AI(I,M-1)=YI
         DO 25 J=M,N
            AR(I,J)=AR(I,J)-YR*AR(M,J)+YI*AI(M,J)
            AI(I,J)=AI(I,J)-YR*AI(M,J)-YI*AR(M,J)
25       CONTINUE
         DO 30 J=1,L
            AR(J,M)=AR(J,M)+YR*AR(J,I)-YI*AI(J,I)
            AI(J,M)=AI(J,M)+YR*AI(J,I)+YI*AR(J,I)
30       CONTINUE
35    CONTINUE
40 CONTINUE
45 RETURN
   END
   SUBROUTINE CMPXLR (A,N,IA,W,WK,IER)
   INTEGER              N,IA,IER
   REAL                 A(1),W(1),WK(1)
   INTEGER              JER,IAA,NN,N1,N2,L,M,NM,KA1,K,I,INFER,NPI,
  *                     N2PI,JW,J
   REAL                 RDELP,ZERO,ONE,TEN,THOUS
   DATA                 RDELP/16414000000000000000B/
   DATA                 ZERO,ONE/0.0,1.0/,TEN/10.0/,THOUS/1000.0/
   IER = 0
   JER = 0
   IAA = IA+IA
   NN = N+N
   N1 = 1
   N2 = 1
   L = 1
   M = 1
   NM = N1-1
   KA1 = 2
   DO 45 J = 1,N
      K = KA1
      DO 30 I = 1,N
         WK(NM+I) = A(K)
         A(L) = A(K-1)
         K = K+2
         L = L+1
30    CONTINUE
      DO 40 I = 1,N
         A(L) = WK(NM+I)
```

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```
         L = L+1
   40    CONTINUE
         KA1 = KA1+IAA
   45 CONTINUE
      CALL BALANCE (A(1),A(N+1),N,NN,K,L,WK(N1))
      CALL HESSC (A(1),A(N+1),K,L,N,NN,WK(N2))
      CALL EIGLRC (A(1),A(N+1),K,L,N,NN,W(1),W(N+1),INFER,JER)
      N2 = N2-1
      DO 60 I=1,N
         NPI = N+I
         N2PI = N2+I
         WK(N2PI) = W(NPI)
   60 CONTINUE
      JW = N+N
      J = N
      DO 65 I=1,N
         W(JW-1) = W(J)
         N2PJ = N2+J
         W(JW) = WK(N2PJ)
         JW = JW-2
         J = J-1
   65 CONTINUE
      IF (IER .NE. 0) CALL UERTST (IER,6HCMPXLR)
      IF (JER .EQ. 0) GO TO 9005
      IER = JER+INFER
      CALL UERTST (IER,6HCMPXLR)
 9005 RETURN
      END
      SUBROUTINE EIGLRC (HR,HI,K,L,N,IH,WR,WI,INFER,IER)
      INTEGER            K,L,N,IH,INFER,IER
      REAL               HR(IH,1),HI(IH,1),WR(1),WI(1)
      INTEGER            I,NN,ITS,NM1,NPL,LL,M,MM1,NMJ,J,M1,MM,MP1,
     *                   IM1,JM1
      REAL               T1(2),T2(2),T3(2),ZERO,ONE,TWO,RDELP,TR,TI,
     *                   SR,SI,XR,XI,YR,YI,ZR,ZI
      COMPLEX            X,Y,Z
      EQUIVALENCE        (X,T1(1)),(T1(1),XR),(T1(2),XI),
     1                   (Y,T2(1)),(T2(1),YR),(T2(2),YI),
     2                   (Z,T3(1)),(T3(1),ZR),(T3(2),ZI)
      DATA               ZERO,ONE,TWO/0.0,1.0,2.0/
      DATA               RDELP/164140000000000000000B/
      INFER=0
      IER=0
      DO 5 I=1,N
         IF (I .GE. K .AND. I .LE. L) GO TO 5
         WR(I)=HR(I,I)
         WI(I)=HI(I,I)
    5 CONTINUE
```

```
      NN=L                                                    COSAL     3169
      TR=ZERO                                                 COSAL     3170
      TI=ZERO                                                 COSAL     3171
   10 IF (NN .LT. K) GO TO 9005                               COSAL     3172
      ITS=0                                                   COSAL     3173
      NM1=NN-1                                                COSAL     3174
      IF (NN .EQ. K) GO TO 25                                 COSAL     3175
   15 NPL=NN+K                                                COSAL     3176
      DO 20 LL=K,NM1                                          COSAL     3177
         M=NPL-LL                                             COSAL     3178
         MM1=M-1                                              COSAL     3179
         IF ( ABS(HR(M,MM1)) +  ABS(HI(M,MM1)) .LE.           COSAL     3180
     1    RDELP*( ABS(HR(MM1,MM1)) +  ABS(HI(MM1,MM1)) +      COSAL     3181
     2        ABS(HR(M,M)) +  ABS(HI(M,M)))) GO TO 30         COSAL     3182
   20 CONTINUE                                                COSAL     3183
   25 M=K                                                     COSAL     3184
   30 IF (M .EQ. NN) GO TO 110                                COSAL     3185
      IF (ITS .EQ. 30) GO TO 115                              COSAL     3186
      IF (ITS .EQ. 10 .OR. ITS .EQ. 20) GO TO 35              COSAL     3187
      SR=HR(NN,NN)                                            COSAL     3188
      SI=HI(NN,NN)                                            COSAL     3189
      XR=HR(NM1,NN)*HR(NN,NM1)-HI(NM1,NN)*HI(NN,NM1)          COSAL     3190
      XI=HR(NM1,NN)*HI(NN,NM1)+HI(NM1,NN)*HR(NN,NM1)          COSAL     3191
      IF (XR .EQ. ZERO .AND. XI .EQ. ZERO) GO TO 40           COSAL     3192
      YR=(HR(NM1,NM1)-SR)/TWO                                 COSAL     3193
      YI=(HI(NM1,NM1)-SI)/TWO                                 COSAL     3194
      Z= CSQRT( CMPLX(YR**2-YI**2+XR,TWO*YR*YI+XI))           COSAL     3195
      IF (YR*ZR+YI*ZI .LT. ZERO) Z=-Z                         COSAL     3196
      X=X/(Y+Z)                                               COSAL     3197
      SR=SR-XR                                                COSAL     3198
      SI=SI-XI                                                COSAL     3199
      GO TO 40                                                COSAL     3200
   35 SR= ABS(HR(NN,NM1))+ ABS(HR(NM1,NN-2))                  COSAL     3201
      SI= ABS(HI(NN,NM1))+ ABS(HI(NM1,NN-2))                  COSAL     3202
   40 DO 45 I=K,NN                                            COSAL     3203
         HR(I,I)=HR(I,I)-SR                                   COSAL     3204
         HI(I,I)=HI(I,I)-SI                                   COSAL     3205
   45 CONTINUE                                                COSAL     3206
      TR=TR+SR                                                COSAL     3207
      TI=TI+SI                                                COSAL     3208
      ITS=ITS+1                                               COSAL     3209
      XR= ABS(HR(NM1,NM1))+ ABS(HI(NM1,NM1))                  COSAL     3210
      YR= ABS(HR(NN,NM1))+ ABS(HI(NN,NM1))                    COSAL     3211
      ZR= ABS(HR(NN,NN))+ ABS(HI(NN,NN))                      COSAL     3212
      NMJ=NM1-M                                               COSAL     3213
      IF (NMJ .EQ. 0) GO TO 55                                COSAL     3214
      DO 50 J=1,NMJ                                           COSAL     3215
         MM=NN-J                                              COSAL     3216
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```
      M1=MM-1                                                           COSAL 3217
      YI=YR                                                             COSAL 3218
      YR= ABS(HR(MM,M1))+ ABS(HI(MM,M1))                                COSAL 3219
      XI=ZR                                                             COSAL 3220
      ZR=XR                                                             COSAL 3221
      XR= ABS(HR(M1,M1))+ ABS(HI(M1,M1))                                COSAL 3222
      IF (YR.LE.RDELP*ZR/YI*(ZR+XR+XI)) GO TO 60                        COSAL 3223
   50 CONTINUE                                                          COSAL 3224
   55 MM=M                                                              COSAL 3225
   60 MP1=MM+1                                                          COSAL 3226
      DO 85 I=MP1,NN                                                    COSAL 3227
         IM1=I-1                                                        COSAL 3228
         XR=HR(IM1,IM1)                                                 COSAL 3229
         XI=HI(IM1,IM1)                                                 COSAL 3230
         YR=HR(I,IM1)                                                   COSAL 3231
         YI=HI(I,IM1)                                                   COSAL 3232
         IF ( ABS(XR)+ ABS(XI) .GE.  ABS(YR)+ ABS(YI)) GO TO 70         COSAL 3233
         DO 65 J=IM1,NN                                                 COSAL 3234
            ZR=HR(IM1,J)                                                COSAL 3235
            HR(IM1,J)=HR(I,J)                                           COSAL 3236
            HR(I,J)=ZR                                                  COSAL 3237
            ZI=HI(IM1,J)                                                COSAL 3238
            HI(IM1,J)=HI(I,J)                                           COSAL 3239
            HI(I,J)=ZI                                                  COSAL 3240
   65    CONTINUE                                                       COSAL 3241
         Z=X/Y                                                          COSAL 3242
         WR(I)=ONE                                                      COSAL 3243
         GO TO 75                                                       COSAL 3244
   70    Z=Y/X                                                          COSAL 3245
         WR(I)=-ONE                                                     COSAL 3246
   75    HR(I,IM1)=ZR                                                   COSAL 3247
         HI(I,IM1)=ZI                                                   COSAL 3248
         DO 80 J=I,NN                                                   COSAL 3249
            HR(I,J)=HR(I,J)-ZR*HR(IM1,J)+ZI*HI(IM1,J)                   COSAL 3250
            HI(I,J)=HI(I,J)-ZR*HI(IM1,J)-ZI*HR(IM1,J)                   COSAL 3251
   80    CONTINUE                                                       COSAL 3252
   85 CONTINUE                                                          COSAL 3253
      DO 105 J=MP1,NN                                                   COSAL 3254
         JM1=J-1                                                        COSAL 3255
         XR=HR(J,JM1)                                                   COSAL 3256
         XI=HI(J,JM1)                                                   COSAL 3257
         HR(J,JM1)=ZERO                                                 COSAL 3258
         HI(J,JM1)=ZERO                                                 COSAL 3259
         IF (WR(J) .LE. ZERO) GO TO 95                                  COSAL 3260
         DO 90 I=M,J                                                    COSAL 3261
            ZR=HR(I,JM1)                                                COSAL 3262
            HR(I,JM1)=HR(I,J)                                           COSAL 3263
            HR(I,J)=ZR                                                  COSAL 3264
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      ZI=HI(I,JM1)                                           COSAL    3265
      HI(I,JM1)=HI(I,J)                                      COSAL    3266
      HI(I,J)=ZI                                             COSAL    3267
   90 CONTINUE                                               COSAL    3268
   95 DO 100 I=M,J                                           COSAL    3269
      HR(I,JM1)=HR(I,JM1)+XR*HR(I,J)-XI*HI(I,J)              COSAL    3270
      HI(I,JM1)=HI(I,JM1)+XR*HI(I,J)+XI*HR(I,J)              COSAL    3271
  100 CONTINUE                                               COSAL    3272
  105 CONTINUE                                               COSAL    3273
      GO TO 15                                               COSAL    3274
  110 WR(NN)=HR(NN,NN)+TR                                    COSAL    3275
      WI(NN)=HI(NN,NN)+TI                                    COSAL    3276
      NN=NM1                                                 COSAL    3277
      GO TO 10                                               COSAL    3278
  115 INFER=NN                                               COSAL    3279
      IER=129                                                COSAL    3280
      CALL UERRTST (IER,6HEIGLRC)                            COSAL    3281
 9005 RETURN                                                 COSAL    3282
      END                                                    COSAL    3283
      SUBROUTINE UERRTST (IER,NAME)                          COSAL    3284
      INTEGER            IER,NAME                            COSAL    3285
      INTEGER            NAMSET,NAMEQ                        COSAL    3286
      DATA               NAMSET/6HUERSET/                    COSAL    3287
      DATA               NAMEQ/6H      /                     COSAL    3288
      DATA               LEVEL/4/,IEQDF/0/,IEQ/1H=/          COSAL    3289
      IF (IER.GT.999) GO TO 25                               COSAL    3290
      IF (IER.LT.-32) GO TO 55                               COSAL    3291
      IF (IER.LE.128) GO TO 5                                COSAL    3292
      IF (LEVEL.LT.1) GO TO 30                               COSAL    3293
      CALL GETIOU(1,NIN,IOUNIT)                              COSAL    3294
      IF (IEQDF.EQ.1) WRITE(IOUNIT,35) IER,NAMEQ,IEQ,NAME    COSAL    3295
      IF (IEQDF.EQ.0) WRITE(IOUNIT,35) IER,NAME              COSAL    3296
      GO TO 30                                               COSAL    3297
    5 IF (IER.LE.64) GO TO 10                                COSAL    3298
      IF (LEVEL.LT.2) GO TO 30                               COSAL    3299
      CALL GETIOU(1,NIN,IOUNIT)                              COSAL    3300
      IF (IEQDF.EQ.1) WRITE(IOUNIT,40) IER,NAMEQ,IEQ,NAME    COSAL    3301
      IF (IEQDF.EQ.0) WRITE(IOUNIT,40) IER,NAME              COSAL    3302
      GO TO 30                                               COSAL    3303
   10 IF (IER.LE.32) GO TO 15                                COSAL    3304
      IF (LEVEL.LT.3) GO TO 30                               COSAL    3305
      CALL GETIOU(1,NIN,IOUNIT)                              COSAL    3306
      IF (IEQDF.EQ.1) WRITE(IOUNIT,45) IER,NAMEQ,IEQ,NAME    COSAL    3307
      IF (IEQDF.EQ.0) WRITE(IOUNIT,45) IER,NAME              COSAL    3308
      GO TO 30                                               COSAL    3309
   15 CONTINUE                                               COSAL    3310
      IF (NAME.NE.NAMSET) GO TO 25                           COSAL    3311
      LEVOLD = LEVEL                                         COSAL    3312
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```
      LEVEL = IER
      IER = LEVOLD
      IF (LEVEL.LT.0) LEVEL = 4
      IF (LEVEL.GT.4) LEVEL = 4
      GO TO 30
   25 CONTINUE
      IF (LEVEL.LT.4) GO TO 30
      CALL GETIOU(1,NIN,IOUNIT)
      IF (IEODF.EQ.1) WRITE(IOUNIT,50) IER,NAMEO,IEO,NAME
      IF (IEODF.EQ.0) WRITE(IOUNIT,50) IER,NAME
   30 IEODF = 0
      RETURN
   35 FORMAT(19H *** TERMINAL ERROR,10X,7H(IER = ,I3,
     1       20H) FROM SUBROUTINE-- ,A6,A1,A6)
   40 FORMAT(36H *** WARNING WITH FIX ERROR  (IER = ,I3,
     1       20H) FROM SUBROUTINE-- ,A6,A1,A6)
   45 FORMAT(18H *** WARNING ERROR,11X,7H(IER = ,I3,
     1       20H) FROM SUBROUTINE-- ,A6,A1,A6)
   50 FORMAT(20H *** UNDEFINED ERROR,9X,7H(IER = ,I5,
     1       20H) FROM SUBROUTINE-- ,A6,A1,A6)
   55 IEODF = 1
      NAMEO = NAME
      RETURN
      END
      SUBROUTINE GETIOU(IOPT,NIN,NOUT)
      INTEGER              IOPT,NIN,NOUT
      INTEGER              NIND,NOUTD
      DATA                 NIND/5LINPUT/,NOUTD/6LOUTPUT/
      IF (IOPT.EQ.3) GO TO 10
      IF (IOPT.EQ.2) GO TO 5
      IF (IOPT.NE.1) GO TO 9005
      NIN = NIND
      NOUT = NOUTD
      GO TO 9005
    5 NIND = NIN
      GO TO 9005
   10 NOUTD = NOUT
 9005 RETURN
      END
```

APPENDIX B

Listing of WING

```
      PROGRAM WING(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7)
C     THIS PROGRAM CALCULATES THE LAMINAR BOUNDARY LAYER ON TAPERED
C
C     AND SWEPT WINGS WITH ADIABATIC WALL TEMPERATURE
C     INPUTS ARE: STREAMWISE AIRFOIL COORDINATES, PRESSURE
C     DISTRIBUTION IN TERMS OF CP, AND MASS FLOW RATE THROUGH THE
C     WALL
C     CALCULATIONS ARE BASED ON CONICAL FLOW ASSUMPTIONS
C
      COMMON /BLC0/ NZT,NZ,NP,IT,X,POFS,CMACH,TT,ETA(101),DETA(101),A(10
     11),Y(101)
      COMMON /BLC1/ HE,PR,CMUFS,UFS,CEL(51),BETA1(51),UE(51),WE(51),Z(51
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),PP(
     251),ALP(51)
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,
     12),T(101,2),R(101,2),C(101),BC(101,2),E(101,2),DENP(101,2),CA1(101
     2,2),CA2(101,2)
      COMMON /PAR/ TWRT,A1,A2,A3,VGP
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
1     CALL INTIAL
      NZ=1
      ISOLV2=0
      IFLOW=0
      ITMAX=10
C
2     IGROW=0
      WRITE (6,11) NZ,XC(NZ)
3     IT=0
4     IT=IT+1
      IF (IT.LE.ITMAX) GO TO 5
      WRITE (6,10)
      GO TO 9
C
5     IF (ISOLV2.EQ.1) CALL FLUID
      CALL COEF
      CALL SOLV6
C
C     CHECK FOR CONVERGENCE
      IF (ABS(DELV(1)).LE.0.0001) GO TO 6
      IF (ISOLV2.EQ.1) CALL SOLV2
      GO TO 4
C
C     ADD ENERGY EQUATION AFTER CONVERGENCE
6     IF (ISOLV2.EQ.0) GO TO 7
      CALL SOLV2
      GO TO 8
7     IF (CMACH.EQ.0.0) GO TO 8
      ISOLV2=1
```

```
      GO TO 3                                                           WING
C                                                                       WING
C     ETAE GROWTH AFTER CONVERGENCE                                     WING
8     IF (ABS(T(NP,2)).LE.1.E-8) GO TO 9                                WING
      IF (NP.EQ.101) GO TO 9                                            WING
      IGROW=IGROW+1                                                     WING
      IF (IGROW.GT.1) GO TO 9                                           WING
      LL=1                                                              WING
      CALL PROFIL (LL)                                                  WING
      GO TO 3                                                           WING
C                                                                       WING
9     CALL OUTPUT                                                       WING
      IF (NZ.GT.NZT) CALL EXIT                                          WING
      GO TO 2                                                           WING
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - WING
C                                                                       WING
C                                                                       WING
10    FORMAT (1H0,23HITERATIONS EXCEED ITMAX)                           WING
11    FORMAT (1H0,4HNZ =,I3,5X,5HX/C =,E14.6)                           WING
      END                                                               WING
      SUBROUTINE INTIAL                                                 WING
      COMMON /BLCO/ NZT,NZ,NP,IT,X,RDFS,CMACH,TT,ETA(101),DETA(101),A(10WING
     11),Y(101)                                                         WING
      COMMON /BLC1/ HE,PR,CMUFS,UFS,CEL(51),BETA1(51),UE(51),WE(51),Z(51WING
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),PP(WING
     251),BLP(51)                                                       WING
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,WING
     12),T(101,2),B(101,2),C(101),BG(101,2),E(101,2),DENP(101,2),CA1(101WING
     2,2),CA2(101,2)                                                    WING
      COMMON /PAR/ IWRT,A1,A2,A3,VGP                                    WING
      DIMENSION TITLE(20), DUE(51), DWE(51), DDW(51), DPR(51)           WING
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - WING
      READ (5,23) TITLE                                                 WING
      READ (5,31) IWRT                                                  WING
      READ (5,24) NI,NZT,ETAE,DETA1,VGP                                 WING
      READ (5,25) X,SWLE,SWTE,CMACH,UREF,TPRES,TT,PR                    WING
      XINPUT=X                                                          WING
      READ (5,25) (A(I),I=1,NI)                                         WING
      READ (5,25) (Y(I),I=1,NI)                                         WING
      READ (5,25) (XC(I),I=1,NZT)                                       WING
      READ (5,25) (P4(I),I=1,NZT)                                       WING
      READ (5,25) (BLP(I),I=1,NZT)                                      WING
      CMSQ=CMACH**2                                                     WING
      RDFS=TPRES/(1716.*TT)                                             WING
      UFS=CMACH*SQRT(1.4*1716.*TT)                                      WING
      IF (CMACH.EQ.0.0) UFS=UREF                                        WING
      CMUFS=2.27E-08*TT**1.5/(TT+198.6)                                 WING
      TTT=TT*(1.0+0.2*CMSQ)                                             WING
```

```
      HF=TTT*6006.0
      REY=UFS*RDFS*YINPUT/CMUFS
      A1=1.+VGP
      A2=A1+VGP**2
      A3=A2+VGP**3
C
C     CALCULATE SURFACE COORDINATE THETA
C
      DEL=ACOS(1.0-A(1))
      ETA(1)=DEL
      IF (A(1).GT.A(2)) ETA(1)=-DEL
      DO 3 I=2,NT
      PHANG=ACOS(1.0-A(I))
      IF (A(I).LT.A(I-1)) GO TO 1
      ETA(I)=PHANG
      GO TO 2
1     ETA(I)=-PHANG
2     IF (A(I).EQ.0.0) ETA(I)=0.0
3     CONTINUE
      CALL SPLINE (Y,ETA,NT,DELV)
      TLE=TAN(0.0174533*SWLE)
      TTE=TAN(0.0174533*SWTE)
      CB=TLE-TTE
      Y=Y*SQRT(1.0+TLE**2)/CB
      DO 4 I=1,NT
      SF=SIN(ETA(I))
      TCS=TLE-CB*A(I)
      FF=1.0+(CB*Y(I))**2+TCS*TCS
      DF=2.0*CB*(-TCS*SF+CB*Y(I)*DELV(I))
      XF=(CB*SF+TCS*DF/FF/2.0)**2
      YF=0.25*(DF/FF)**2
      ZF=(CB*(DELV(I)-Y(I)*DF/FF/2.0))**2
      DETA(I)=SQRT((XF+YF+ZF)/FF)
4     CONTINUE
      CALL INTEG (ETA,DETA,C,NT)
C
C     CALCULATE VELOCITY COMPONENTS
C
      DO 10 I=1,NZT
      IF (CMACH.EQ.0.0) GO TO 5
      DPR(I)=1.0+0.7*P4(I)*CMSQ
      PF(I)=1.0+(1.0-DPR(I)**0.285714)/(0.2*CMSQ)
      GO TO 6
5     PF(I)=1.0-P4(I)
      DPR(I)=1.0+UREF*UREF*P4(I)/TT/3432.0
6     IF (I.GT.1) GO TO 7
      DEL=ACOS(1.0-XC(I))
      P3(1)=DEL
```

```
      IF (XC(1).GT.XC(2)) P3(1)=-DEL
      GO TO 10
7     PHANG=ACOS(1.0-XC(I))
      IF (XC(I).LT.XC(I-1)) GO TO 8
      P3(I)=PHANG
      GO TO 9
8     P3(I)=-PHANG
9     IF (XC(I).EQ.0.0) P3(I)=0.0
10    CONTINUE
      CALL CUBIC (C,ETA,NI,P3,NZT,Z)
      DUE(1)=SQRT(PE(1))
      DWE(1)=0.0
      NUM=1
      DZ1=Z(1)
      Z(1)=0.0
      CR=CB*CB/(1.0+TLE**2)
      CC=2.0*TLE/CB
      RR(1)=0.0
      DO 11 I=2,NZT
      Z(I)=Z(I)-DZ1
      DZ=Z(I)-Z(I-1)
      RR(I)=RR(I-1)+DZ*X
      G1=-DWE(I-1)*DZ
      P1(1)=Z(I-1)+0.5*DZ
      CALL CUBIC (PE,Z,NZT,P1,NUM,UE)
      G2TRM=-(DUE(I-1)+G1/2.0)**2+UE(1)
      IF (G2TRM.LT.0.0) G2TRM=0.0
      G2=-SQRT(G2TRM)*DZ
      G3TRM=-(DUE(I-1)+G2/2.0)**2+UE(1)
      IF (G3TRM.LT.0.0) G3TRM=0.0
      G3=-SQRT(G3TRM)*DZ
      G4TRM=PE(I)-(DUE(I-1)+G3)**2
      IF (G4TRM.LT.0.0) G4TRM=0.0
      G4=-SQRT(G4TRM)*DZ
      DUE(I)=DUE(I-1)+(G1+2.0*G2+2.0*G3+G4)/6.0
      DWE(I)=SQRT(PE(I)-DUE(I)**2)
11    CONTINUE
      CALL SPLINE (DWE,Z,NZT,EDW)
      DEW(1)=-2.0*(DUE(2)-DUE(1))/Z(2)/Z(2)
C
      IF (IWRT.NE.0.AND.IWRT.NE.2) GO TO 13
      WRITE (7) TITLE
      WRITE (7) NZT,X,XINPUT
      DO 12 I=1,NZT
      DUM2=DWE(I)*UES
      WRITE (7) XC(I),Z(I),DUM2
12    CONTINUE
13    CONTINUE
```

```
      WRITE (6,27) TITLE
      WRITE (6,28) CMACH,UFS,TPPFS,TT,PR,ROFS,CMUFS,REY,XINPUT,X,SWLE,SW
     1TE,NI,NZT,ETAE,DETA1,VGP
      WRITE (6,29) (I,A(I),Y(I),I=1,NI)
      WRITE (6,30) (I,XC(I),Z(I),PR(I),P4(I),BLP(I),DUE(I),DWE(I),DDW(I)
     1,CPK(I),I=1,NZT)
C
C     CALCULATE COEFFICIENTS FOR BL EQNS.
C
      UFS2=UFS**2
      DO 16 J=1,NZT
      UE(J)=UFS*DUE(J)
      WE(J)=UFS*DWE(J)
      BETA1(J)=DWE(J)/DUE(J)
      PE(J)=DPR(J)*TPRFS
      IF (CMACH.EQ.0.0) GO TO 14
      TE=TT*(1.0-0.2*CMSQ*(DUE(J)**2+DWE(J)**2-1.0))
      S=(-DWE(J)*(DDW(J)-DUE(J))*(UFS2/(1716.*TE))*(1.0+(198.6-TE)/(7.0*
     1(198.6+TE))))
      RHOE(J)=PE(J)/(1716.*TE)
      GO TO 15
14    TE=TT
      S=0.0
      RHOE(J)=ROFS
15    CMUE(J)=2.27E-08*(TE**1.5/(TE+198.6))
      P1(J)=DDW(J)/DUE(J)
      P4(J)=BETA1(J)**2
      P3(J)=0.5*(2.0*DDW(J)/DUE(J)+P4(J)+S*BETA1(J))
      BLP(J)=SQRT(UE(J)*RHOE(J)*X/CMUE(J))*BLP(J)*UFS*ROFS/RHOE(J)/UE(J)
      IF (J.EQ.1) GO TO 16
      BETA1B=0.5*(BETA1(J)+BETA1(J-1))
      CEL(J)=BETA1B/(Z(J)-Z(J-1))
16    CONTINUE
      CEL(1)=0.0
C
C     DEFINE NUMBER OF POINTS AND GRID
C
      DETA(1)=DETA1
      ETA(1)=0.0
      IF ((VGP-1.0).LE.0.001) GO TO 17
      NP=ALOG((ETAE/DETA(1))*(VGP-1.0)+1.0)/ALOG(VGP)+1.001
      GO TO 18
17    NP=ETAE/DETA(1)+1.001
18    IF (NP.LE.101) GO TO 19
      WRITE (6,26)
      NP=101
19    DO 20 J=2,101
      DETA(J)=DETA(J-1)*VGP
```

```
      ETA(J)=ETA(J-1)+DETA(J-1)
20    A(J)=0.5*DETA(J-1)
      LL=0
      CALL PROFIL (LL)
      RETURN
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C
21    FORMAT (I5,2E20.13)
22    FORMAT (4E20.13)
23    FORMAT (20A4)
24    FORMAT (2I3,3F10.0)
25    FORMAT (8F10.0)
26    FORMAT (1H0,36HNP EXCEEDED DIMENSIONS -- SET TO 101)
27    FORMAT (1H0,20A4)
28    FORMAT (1H0,7HMACHN =,E14.6,3X,7HUFS    =,E14.6,3X,7HPFS    =,E14.6,
     13X,7HTFS    =,E14.6,3X,7HPR     =,E14.6/1H0,7HRDFS   =,E14.6,3X,7HMUF
     2S   =,E14.6,3X,7HREC    =,E14.6/1H0,7HCHORD  =,E14.6,3X,7HRADIUS=,E14
     3.6,3X,7HLESW   =,E14.6,3X,7HTESW   =,E14.6/1H0,7HNI     =,I3,14X,7HNZ
     4     =,I3,14X,7HETAE   =,E14.6,3X,7HDETA1 =,E14.6,3X,7HVGP    =,E14.6
     5/)
29    FORMAT (//1H0,4X,30HSTREAMWISE AIRFOIL COORDINATES/1H0,3H NI,8X,3H
     1X/C,16X,3HZ/C/(1H ,I3,3X,E14.6,5X,E14.6))
30    FORMAT (1H0,58X,12HSTATION DATA/1H0,1X,2HNZ,5X,3HY/C,10X,5HTHETA,1
     11X,1HS,13X,2HCP,11X,3HCOL,10X,5HUEUFS,9X,5HWEUFS,9X,6HDWEUFS,8X,5H
     2PEPFS/(1H ,I3,9E14.6))
31    FORMAT (I1)
      END
      SUBROUTINE PROFIL (L)
      COMMON /BLC0/ NZT,NZ,NP,IT,X,RDFS,CMACH,TT,ETA(101),DETA(101),A(10
     11),Y(101)
      COMMON /BLC1/ HE,PR,CMUFS,UFS,CEL(51),BETA1(51),UE(51),WE(51),Z(51
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),PP(
     251),3LP(51)
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,
     12),T(101,2),R(101,2),C(101),BG(101,2),E(101,2),DENR(101,2),CA1(101
     2,2),CA2(101,2)
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      IF (L.EQ.1) GO TO 2
C
C     DEFINE INITIAL PROFILES
      E(1,2)=0.0
      BG(1,2)=1.0
      BG1=4.0*(BG(1,2)-1.0)
      BG2=4.0*(1.0-BG(1,2))
      DO 1 J=1,NP
      ETAE=ETA(J)/ETA(NP)
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      F(J,2)=0.5*ETAB*ETA(J)
      U(J,2)=ETAB
      V(J,2)=1.0/ETA(NP)
      G(J,2)=F(J,2)
      W(J,2)=U(J,2)
      T(J,2)=V(J,2)
      DENR(J,2)=1.0
      B(J,2)=1.0
      C(J)=1.C
      BG(J,2)=1.0
1     CONTINUE
      RETURN
C
C     PROFILES FOR ETAE GROWTH
2     NP1=NP+1
      NP11=NP1-1
      NP=NP+3
      IF (NP.GT.101) NP=101
      KK=1
      IF (N7.EQ.1) KK=2
      DO 4 K=KK,2
      DO 3 J=NP1,NP
      DENR(J,K)=DENR(NP11,K)
      C(J)=1.0
      F(J,K)=ETA(J)+F(NP11,K)-ETA(NP11)
      U(J,K)=1.0
      V(J,K)=V(NP11,K)
      G(J,K)=ETA(J)+G(NP11,K)-ETA(NP11)
      W(J,K)=1.0
      T(J,K)=T(NP11,K)
      B(J,K)=B(NP11,K)
      IF (CMACH.EQ.C.0) GO TO 3
      BG(J,K)=1.0
      E(J,K)=E(NP11,K)
      CA1(J,K)=CA1(NP11,K)
      CA2(J,K)=CA2(NP11,K)
3     CONTINUE
4     CONTINUE
      RETURN
      END
      SUBROUTINE CUBIC (YL,XL,IN,FI,NP,PP)
      DIMENSION YL(1), XL(1), FI(1), PP(1)
      DO 8 I=1,NP
      DO 2 J=1,IN
      IF ((FI(I)-YL(J)).LE.0.0) GO TO 1
      GO TO 2
1     K2=J
      GO TO 3
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2     CONTINUE                                                          WING 337
      K2=IN                                                             WING 338
3     IF (I.EQ.1) K1=100                                                WING 339
      IF (K2.EQ.K1) GO TO 7                                             WING 340
      IF (K2.GT.2.AND.K2.LT.IN) GO TO 5                                 WING 341
      IF (K2.EQ.IN) GO TO 4                                             WING 342
      L=3                                                               WING 343
      GO TO 6                                                           WING 344
4     L=IN-1                                                            WING 345
      GO TO 6                                                           WING 346
5     L=K2                                                              WING 347
6     A=-(XL(L-1)-XL(L-2))*(XL(L)-XL(L-2))*(XL(L+1)-XL(L-2))            WING 348
      B=(XL(L-1)-XL(L-2))*(XL(L)-XL(L-1))*(XL(L+1)-XL(L-1))             WING 349
      C=-(XL(L)-XL(L-2))*(XL(L)-XL(L-1))*(XL(L+1)-XL(L))                WING 350
      D=(XL(L+1)-XL(L-2))*(XL(L+1)-XL(L-1))*(XL(L+1)-XL(L))             WING 351
7     A1=(FI(I)-XL(L))*(FI(I)-XL(L+1))                                  WING 352
      A6=(FI(I)-XL(L-2))*(FI(I)-XL(L-1))                                WING 353
      PP(I)=(FI(I)-XL(L-1))*A1*YL(L-2)/A+(FI(I)-XL(L-2))*A1*YL(L-1)/B+(FWING 354
     1I(I)-XL(L+1))*A6*YL(L)/C+(FI(I)-XL(L))*YL(L+1)*A6/D               WING 355
      K1=K2                                                             WING 356
8     CONTINUE                                                          WING 357
      RETURN                                                            WING 358
      END                                                               WING 359
      SUBROUTINE SPLINE (X,FI,IN,XP)                                    WING 360
      DIMENSION X(1), FI(1), XP(1), OJ(61), UJ(61)                      WING 361
      OJ(1)=-1.0                                                        WING 362
      UJ(1)=2.0*(X(2)-X(1))/(FI(2)-FI(1))                               WING 363
      DO 3 I=2,IN                                                       WING 364
      AJ=FI(I)-FI(I-1)                                                  WING 365
      IF (I.EQ.IN) GO TO 1                                              WING 366
      BJ=FI(I+1)-FI(I)                                                  WING 367
      CJ=AJ/(AJ+BJ)                                                     WING 368
      DJ=3.0*(CJ*(X(I+1)-X(I))/BJ+(1.0-CJ)*(X(I)-X(I-1))/AJ)            WING 369
      GO TO 2                                                           WING 370
1     DJ=2.0*(X(I)-X(I-1))/AJ                                           WING 371
      CJ=0.0                                                            WING 372
2     PJ=(1.0-CJ)*OJ(I-1)+2.0                                           WING 373
      IF (I.EQ.IN) PJ=PJ-1.0                                            WING 374
      OJ(I)=-CJ/PJ                                                      WING 375
      UJ(I)=(DJ-(1.0-CJ)*UJ(I-1))/PJ                                    WING 376
3     CONTINUE                                                          WING 377
      XP(IN)=UJ(IN)                                                     WING 378
      INM1=IN-1                                                         WING 379
      DO 4 I=1,INM1                                                     WING 380
      NR=IN-I                                                           WING 381
      XP(NR)=OJ(NR)*XP(NR+1)+UJ(NR)                                     WING 382
4     CONTINUE                                                          WING 383
      RETURN                                                            WING 384
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      END
      SUBROUTINE INTEG (X,Y,TAB,NPT)                                      WING
      DIMENSION X(1), Y(1), TAB(1)                                        WING
C     SUBROUTINE ITS1                                                     WING
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - WING
      IF (NPT.LT.4) GO TO 6                                               WING
      DO 5 I=1,NPT                                                        WING
      TAB(I)=0.0                                                          WING
      K=I-1                                                               WING
      IF (I-2) 5,3,1                                                      WING
    1 IF (I.LT.NPT) GO TO 2                                               WING
      K=K-1                                                               WING
    2 K=K-1                                                               WING
    3 A=X(I)                                                              WING
      B=X(I-1)                                                            WING
      L=K+1                                                               WING
      M=K+2                                                               WING
      N=K+3                                                               WING
      DO 4 J=1,4                                                          WING
      XL=X(L)                                                             WING
      XN=X(N)                                                             WING
      XM=X(M)                                                             WING
      XK=X(K)                                                             WING
      YK=Y(K)                                                             WING
      SUM=YK/((XK-XM)*(XK-XN)*(XK-XL))                                    WING
      SUM1=((A**4)-(B**4))/4.0                                            WING
      SUM2=(XL+XM+XN)*((A**3)-(B**3))/3.0                                 WING
      SUM3=(XM*XN+XM*XL+XL*XN)*(A**2-B**2)/2.0                            WING
      SUM4=(XM*XN*XL)*(A-B)                                               WING
      SUM=SUM*(SUM1-SUM2+SUM3-SUM4)                                       WING
      TAB(I)=TAB(I)+SUM                                                   WING
      ITEMP=K                                                             WING
      K=N                                                                 WING
      N=M                                                                 WING
      M=L                                                                 WING
    4 L=ITEMP                                                             WING
      TAB(I)=TAB(I)+TAB(I-1)                                              WING
    5 CONTINUE                                                            WING
    6 RETURN                                                              WING
      END                                                                 WING
      SUBROUTINE FLUID                                                    WING
      COMMON /BLCO/ NZT,NZ,NP,IT,X,PDES,CMACH,TT,ETA(101),DETA(101),A(10WING
     11),Y(101)                                                           WING
      COMMON /BLC1/ HE,PR,CMUES,UES,CEL(51),BETA1(51),UE(51),WE(51),Z(51WING
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),PP(WING
     251),RLP(51)                                                         WING
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,WING
     12),T(101,2),B(101,2),C(101),BG(101,2),E(101,2),DENR(101,2),CAI(10)WING
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```
     2,2),CA2(101,2)
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      WW=0.0
      IF (IT.GT.1) GO TO 1
      PE35=3.5*PE(NZ)
      UE2H=0.5*UE(NZ)**2
C
1     DO 2 J=1,NP
      IF (NZ.GT.1) WW=W(J,2)
      H=HE*BG(J,2)-UE2H*(U(J,2)**2+P4(NZ)*WW**2)
      TTT=H/6006.0
      CMU=2.27E-08*TTT**1.5/(TTT+198.6)
      DENR(J,2)=RHOE(NZ)*H/PE35
      C(J)=CMU/(CMUE(NZ)*DENR(J,2))
2     CONTINUE
C
      UE2HE=UE(NZ)**2/HE
      RPR=1.0-1.0/PR
      DO 3 J=1,NP
      CA1(J,2)=C(J)/PR
      CA2(J,2)=(C(J)*UE2HE)*RPR*(U(J,2)*V(J,2)+P4(NZ)*W(J,2)*T(J,2))
      B(J,2)=C(J)
3     CONTINUE
      RETURN
      END
      SUBROUTINE COEF
      COMMON /BLC0/ NZT,NZ,NP,IT,X,PDFS,CMACH,TT,ETA(101),DETA(101),A(10
     11),Y(101)
      COMMON /BLC1/ HE,PR,CMUES,UES,CEL(51),BETA1(51),UE(51),WE(51),Z(51
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),RP(
     251),ALP(51)
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,
     12),T(101,2),R(101,2),C(101),BG(101,2),E(101,2),DENR(101,2),CA1(101
     2,2),CA2(101,2)
      COMMON /BLC8/ B1(101),B2(101),B3(101),B4(101),B5(101),B6(101),B7(1
     101),B8(101),B9(101),B10(101),R1(101),R2(101),R3(101),R4(101),R5(10
     21),R6(101),S1(101),S2(101),S3(101),S4(101),S5(101),S6(101),S7(101)
     3,S8(101),S9(101),S10(101)
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
      P1P=P1(NZ)+CEL(NZ)
      P3P=P3(NZ)+CEL(NZ)
      P4P=P4(NZ)-CEL(NZ)
      P1T2=2.0*P1(NZ)
      P4T2=2.0*P4(NZ)
      P1P2=2.0*P1P
      DO 4 J=2,NP
      UB=0.5*(U(J,2)+U(J-1,2))
      VB=0.5*(V(J,2)+V(J-1,2))
```

```
      CB=0.5*(G(J,2)+G(J-1,2))
      WB=0.5*(W(J,2)+W(J-1,2))
      TB=0.5*(T(J,2)+T(J-1,2))
      DENRB=0.5*(DENR(J,2)+DENR(J-1,2))
      FVB=0.5*(F(J,2)*V(J,2)+F(J-1,2)*V(J-1,2))
      FTB=0.5*(F(J,2)*T(J,2)+F(J-1,2)*T(J-1,2))
      UWB=0.5*(U(J,2)*W(J,2)+U(J-1,2)*W(J-1,2))
      GVB=0.5*(G(J,2)*V(J,2)+G(J-1,2)*V(J-1,2))
      GTB=0.5*(G(J,2)*T(J,2)+G(J-1,2)*T(J-1,2))
      WSB=0.5*(W(J,2)**2+W(J-1,2)**2)
      IF (NZ.GT.1) GO TO 1
C
      CUB=0.0
      CVB=0.0
      CCB=0.0
      CWB=0.0
      CTB=0.C
      CFTB=C.0
      CUWB=C.0
      CGVB=C.0
      CGTB=0.0
      CWSB=0.0
      CDENRB=0.0
C
C     - ATTACHMENT-LINE FLOW
C     DEFINITIONS OF COEFFICIENTS IN DIFFERENCED X-MOM EQ.
      S1(J)=B(J,2)+A(J)*(-1.5*F(J,2)+P1(NZ)*G(J,2)-BLP(NZ))
      S2(J)=-B(J-1,2)+A(J)*(-1.5*F(J-1,2)+P1(NZ)*G(J-1,2)-BLP(NZ))
      S3(J)=-1.5*A(J)*V(J,2)
      S4(J)=-1.5*A(J)*V(J-1,2)
      S5(J)=0.0
      S6(J)=0.0
      S7(J)=A(J)*P1(NZ)*V(J,2)
      S8(J)=A(J)*P1(NZ)*V(J-1,2)
      S9(J)=0.0
      S10(J)=0.0
C     DEFINITIONS OF COEFFICIENTS IN DIFFERENCED Z-MOM EQ.
      B1(J)=S1(J)
      B2(J)=S2(J)
      B3(J)=-1.5*A(J)*T(J,2)
      B4(J)=-1.5*A(J)*T(J-1,2)
      B5(J)=-A(J)*(-U(J,2)+P1T2*W(J,2))
      B6(J)=-A(J)*(-U(J-1,2)+P1T2*W(J-1,2))
      B7(J)=A(J)*W(J,2)
      B8(J)=A(J)*W(J-1,2)
      B9(J)=A(J)*P1(NZ)*T(J,2)
      B10(J)=A(J)*P1(NZ)*T(J-1,2)
      GO TO 2
```

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C
C     GENERAL FLOW
1     CUB=0.5*(U(J,1)+U(J-1,1))
      CVB=0.5*(V(J,1)+V(J-1,1))
      CGB=0.5*(G(J,1)+G(J-1,1))
      CWB=0.5*(W(J,1)+W(J-1,1))
      CTB=0.5*(T(J,1)+T(J-1,1))
      CFTB=0.5*(F(J,1)*T(J,1)+F(J-1,1)*T(J-1,1))
      CFVB=0.5*(F(J,1)*V(J,1)+F(J-1,1)*V(J-1,1))
      CUWB=0.5*(U(J,1)*W(J,1)+U(J-1,1)*W(J-1,1))
      CGVB=0.5*(G(J,1)*V(J,1)+G(J-1,1)*V(J-1,1))
      CGTB=0.5*(G(J,1)*T(J,1)+G(J-1,1)*T(J-1,1))
      CWSB=0.5*(W(J,1)**2+W(J-1,1)**2)
      CDENBB=0.5*(DENB(J,1)+DENB(J-1,1))
C
C     DEFINITIONS OF COEFFICIENTS IN DIFFERENCED X-MOM EQ.
      S1(J)=B(J,2)+A(J)*(-1.5*F(J,2)+P3P*G(J,2)-CEL(NZ)*CGB-BLP(NZ))
      S2(J)=-B(J-1,2)+A(J)*(-1.5*F(J-1,2)+P3P*G(J-1,2)-CEL(NZ)*CGB-BLP(N
     1Z))
      S3(J)=-1.5*A(J)*V(J,2)
      S4(J)=-1.5*A(J)*V(J-1,2)
      S5(J)=A(J)*(P4P*W(J,2)-CEL(NZ)*CWB)
      S6(J)=A(J)*(P4P*W(J-1,2)-CEL(NZ)*CWB)
      S7(J)=A(J)*(P3P*V(J,2)+CEL(NZ)*CVB)
      S8(J)=A(J)*(P3P*V(J-1,2)+CEL(NZ)*CVB)
      S9(J)=A(J)*(P4P*U(J,2)-P4T2*W(J,2)+CEL(NZ)*CUB)
      S10(J)=A(J)*(P4P*U(J-1,2)-P4T2*W(J-1,2)+CEL(NZ)*CUB)
C
C     DEFINITIONS OF COEFFICIENTS IN DIFFERENCED Z-MOM EQ.
      B1(J)=S1(J)
      B2(J)=S2(J)
      B3(J)=-1.5*A(J)*T(J,2)
      B4(J)=-1.5*A(J)*T(J-1,2)
      B5(J)=-A(J)*(P1P2*W(J,2)-U(J,2))
      B6(J)=-A(J)*(P1P2*W(J-1,2)-U(J-1,2))
      B7(J)=A(J)*W(J,2)
      B8(J)=A(J)*W(J-1,2)
      B9(J)=A(J)*(P3P*T(J,2)+CEL(NZ)*CTB)
      B10(J)=A(J)*(P3P*T(J-1,2)+CEL(NZ)*CTB)
C
C     DEFINITION OF RJ
2     R1(J)=F(J-1,2)-F(J,2)+DETA(J-1)*UB
      R2(J)=U(J-1,2)-U(J,2)+DETA(J-1)*VB
      R3(J)=G(J-1,2)-G(J,2)+DETA(J-1)*WB
      R4(J)=W(J-1,2)-W(J,2)+DETA(J-1)*TB
      IF (NZ.GT.1) GO TO 3
      R5(J)=-(B(J,2)*V(J,2)-B(J-1,2)*V(J-1,2)+DETA(J-1)*(-1.5*FVB+P1(NZ)
     1*GVB-BLP(NZ)*VB))
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      R6(J)=-DETA(J-1)*DENRB*(-1.0+P1(NZ))-(B(J,2)*T(J,2)-B(J-1,2)*T(J-1
     1,2)+DETA(J-1)*(-1.5*FTB+P1(NZ)*GTB+UWP-P1(NZ)*WSB-BLP(NZ)*TB))
      GO TO 4
 3    DERBV=(B(J,1)*V(J,1)-B(J-1,1)*V(J-1,1))/DETA(J-1)
      CL5B=DERBV-1.5*CFVB+P3(NZ-1)*CGVB+P4(NZ-1)*(CUWB-CWSB)-BLP(NZ-1)*C
     1VB
      CR5B=-CL5B+CEL(NZ)*(CGVB-CUWB)
      R5(J)=DETA(J-1)*CR5B-(B(J,2)*V(J,2)-B(J-1,2)*V(J-1,2)+DETA(J-1)*(-
     11.5*FVB+P3P*GVB+P4P*UWB-P4(NZ)*WSB-CEL(NZ)*(CWB*UB-CUB*WB-CVB*GB+C
     2GB*VB)-BLP(NZ)*VB))
      DERBT=(B(J,1)*T(J,1)-B(J-1,1)*T(J-1,1))/DETA(J-1)
      CL6B=DERBT-1.5*CFTB+P3(NZ-1)*CGTB+P1(NZ-1)*(CDENRB-CWSB)+CUWB-CDEN
     1RB-BLP(NZ-1)*CTB
      CR6B=-DENRB*(P1(NZ)-1.0)+CEL(NZ)*(CGTB-CWSB)-CL6B
      R6(J)=DETA(J-1)*CR6B-(B(J,2)*T(J,2)-B(J-1,2)*T(J-1,2)+DETA(J-1)*(-
     11.5*FTB+P3P*GTB-P1P*WSB+UWB-CEL(NZ)*(CGB*TB-CTB*GB)-BLP(NZ)*TB))
 4    CONTINUE
      RETURN
      END
      SUBROUTINE SOLVA
      COMMON /BLCO/ NZT,NZ,NP,IT,X,ROFS,CMACH,TT,ETA(101),DETA(101),A(10
     11),Y(101)
      COMMON /BLC1/ HE,PR,CMUFS,UFS,CEL(51),BETA1(51),UE(51),WE(51),Z(51
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),PP(
     251),BLP(51)
      COMMON /PSOF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,
     12),T(101,2),B(101,2),C(101),BG(101,2),E(101,2),DENR(101,2),CA1(101
     2,2),CA2(101,2)
      COMMON /BLCR/ R1(101),R2(101),R3(101),R4(101),R5(101),R6(101),R7(1
     101),R8(101),R9(101),R10(101),P1(101),P2(101),P3(101),P4(101),P5(10
     21),P6(101),S1(101),S2(101),S3(101),S4(101),S5(101),S6(101),S7(101)
     3,S8(101),S9(101),S10(101)
      DIMENSION A11(101), A21(101), A31(101), A41(101), A51(101), A61(10
     11), A12(101), A22(101), A32(101), A42(101), A52(101), A62(101), B1
     21(101), B21(101), B31(101), B41(101), B51(101), B61(101), B12(101)
     3, B22(101), B32(101), B42(101), B52(101), B62(101), DELF(101), DEL
     4U(101), DELT(101), DELG(101), DELW(101), W1(101), W2(101), W3(101)
     5, W4(101), W5(101), W6(101)
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C
C
C     CALCULATION OF GAMMA (AI1,AI2 I=1,6) VECTOR FOR J=2
C     FIRST  AI1
      A11(2)=(S5(2)+S1(2)/A(2)+S3(2)*A(2))/(S2(2)-S1(2))
      A21(2)=(R7(2)+R3(2)*A(2))/(R2(2)-R1(2))
      A31(2)=-A(2)
      A41(2)=-A11(2)-1./A(2)
      A51(2)=0.0
      )
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      A61(2)=-A21(2)
C     THEN  AI2
      A12(2)=(S7(2)*A(2)+S9(2))/(S2(2)-S1(2))
      A22(2)=(B5(2)+A(2)*B9(2)+B1(2)/A(2))/(B2(2)-B1(2))
      A32(2)=0.0
      A42(2)=-A12(2)
      A52(2)=-A(2)
      A62(2)=-A22(2)-1./A(2)
C
C     CALCULATION OF WI(I=1,6) A1(VECTOR)*W(VECTOR)=R(VECTOR), AT J=2
      W1(2)=(B5(2)+(B2(2)*S1(2))/A(2)-S7(2)*B3(2)-S3(2)*B1(2))/(S2(2)-S
     1(2))
      W3(2)=B1(2)
      W4(2)=-W1(2)-B2(2)/A(2)
      W5(2)=B3(2)
      W2(2)=(B6(2)-B1(2)*B4(2)/A(2)-B9(2)*B3(2)-B3(2)*B1(2))/(B2(2)-B1(2
     1))
      W6(2)=-W2(2)-B4(2)/A(2)
C
C     CALCULATION OF ALFA COEFFICIENTS  BI1,BI2 WITH I=1,6
C     NOTE-THE SUBSCRIPT FOR THESE COEF. START FROM 11.
      DO 1 J=3,NP
      B11(J)=-A(J)+A31(J-1)
      B21(J)=-1.0+A(J)*A41(J-1)
      B31(J)=A51(J-1)
      B41(J)=A(J)*A61(J-1)
      B51(J)=S6(J)-S4(J)*A31(J-1)-S2(J)*A41(J-1)-S8(J)*A51(J-1)
      B61(J)=B8(J)-B4(J)*A31(J-1)-B10(J)*A51(J-1)-B2(J)*A61(J-1)
      B12(J)=A32(J-1)
      B22(J)=A42(J-1)*A(J)
      B32(J)=A52(J-1)-A(J)
      B42(J)=A62(J-1)*A(J)-1.0
      B52(J)=-(S4(J)*A32(J-1)+S2(J)*A42(J-1)+S8(J)*A52(J-1))+S10(J)
      B62(J)=B6(J)-B4(J)*A32(J-1)-B10(J)*A52(J-1)-B2(J)*A62(J-1)
C
C     CALCULATION OF AI1,AI2 WITH I=1,6
      CCA1=B51(J)-S3(J)*B11(J)+S1(J)*B21(J)/A(J)-S7(J)*B31(J)
      CB1=B52(J)+S1(J)*B22(J)/A(J)-S7(J)*B32(J)-S3(J)*B12(J)
      CCA2=B61(J)-B3(J)*B11(J)-B9(J)*B31(J)+B1(J)*B41(J)/A(J)
      CB2=B62(J)-B3(J)*B12(J)-B9(J)*B32(J)+B1(J)*B42(J)/A(J)
      CC1=S5(J)+S3(J)*A(J)+S1(J)/A(J)
      CC2=B7(J)+B3(J)*A(J)
      DEN=CCA1*CB2-CB1*CCA2
      A11(J)=(CC1*CB2-CB1*CC2)/DEN
      A21(J)=(CCA1*CC2-CC1*CCA2)/DEN
      A31(J)=-A(J)-B11(J)*A11(J)-B12(J)*A21(J)
      A41(J)=(-1.0+B21(J)*A11(J)+B22(J)*A21(J))/A(J)
      A51(J)=-B31(J)*A11(J)-B32(J)*A21(J)
```

```
      A61(J)=(B41(J)*A11(J)+B42(J)*A21(J))/A(J)
      CC1=S7(J)*A(J)+S9(J)
      CC2=B5(J)+B9(J)*A(J)+B1(J)/A(J)
      A12(J)=(CC1*CB2-CB1*CC2)/DEN
      A22(J)=(CCA1*CC2-CC1*CCA2)/DEN
      A32(J)=-B11(J)*A12(J)-B12(J)*A22(J)
      A42(J)=(B21(J)*A12(J)+B22(J)*A22(J))/A(J)
      A52(J)=-A(J)-B31(J)*A12(J)-B32(J)*A22(J)
      A62(J)=(-1.0+B41(J)*A12(J)+B42(J)*A22(J))/A(J)
      D1=R1(J)+W3(J-1)
      D2=R2(J)+A(J)*W4(J-1)
      D3=R3(J)+W5(J-1)
      D4=R4(J)+A(J)*W6(J-1)
      D5=R5(J)-(S4(J)*W3(J-1)+S2(J)*W4(J-1)+S8(J)*W5(J-1))
      D6=R6(J)-(B4(J)*W3(J-1)+B10(J)*W5(J-1)+B2(J)*W6(J-1))
      CC1=D5-D1*S3(J)+(S1(J)*D2)/A(J)-S7(J)*D3
      CC2=D6-D1*B3(J)+(B1(J)*D4)/A(J)-B9(J)*D3
      W1(J)=(CC1*CB2-CB1*CC2)/DEN
      W2(J)=(CCA1*CC2-CC1*CCA2)/DEN
      W3(J)=D1-B11(J)*W1(J)-B12(J)*W2(J)
      W4(J)=(-D2+B21(J)*W1(J)+B22(J)*W2(J))/A(J)
      W5(J)=D3-B31(J)*W1(J)-B32(J)*W2(J)
      W6(J)=(-D4+B41(J)*W1(J)+B42(J)*W2(J))/A(J)
    1 CONTINUE
C
C     CALCULATION OF PERTURBATION QUANTITIES
      DELU(NP)=0.0
      DELW(NP)=0.0
      DELF(NP)=W3(NP)
      DELV(NP)=W4(NP)
      DELG(NP)=W5(NP)
      DELT(NP)=W6(NP)
      DELU(NP-1)=W1(NP)
      DELW(NP-1)=W2(NP)
      J=NP
    2 J=J-1
      DELU(J-1)=W1(J)-A11(J)*DELU(J)-A12(J)*DELW(J)
      DELW(J-1)=W2(J)-A21(J)*DELU(J)-A22(J)*DELW(J)
      DELF(J)=W3(J)-A31(J)*DELU(J)-A32(J)*DELW(J)
      DELV(J)=W4(J)-A41(J)*DELU(J)-A42(J)*DELW(J)
      DELG(J)=W5(J)-A51(J)*DELU(J)-A52(J)*DELW(J)
      DELT(J)=W6(J)-A61(J)*DELU(J)-A62(J)*DELW(J)
      IF (J.GT.3) GO TO 2
      DELF(2)=W3(2)-A31(2)*DELU(2)-A32(2)*DELW(2)
      DELV(2)=W4(2)-A41(2)*DELU(2)-A42(2)*DELW(2)
      DELG(2)=W5(2)-A52(2)*DELW(2)-A51(2)*DELU(2)
      DELT(2)=W6(2)-A61(2)*DELU(2)-A62(2)*DELW(2)
      DELV(1)=W1(2)-A11(2)*DELU(2)-A12(2)*DELW(2)
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```
      DELT(1)=W2(2)-A21(2)*DELU(2)-A22(2)*DELW(2)                       WING
      DELF(1)=0.0                                                       WING
      DELG(1)=0.0                                                       WING
      DELU(1)=0.0                                                       WING
      DELW(1)=0.0                                                       WING
      IF (IT.EQ.1) WRITE (6,4)                                          WING
      WRITE (6,5) IT,V(1,2),DELV(1),T(1,2),DELT(1)                      WING
      DO 3 J=1,NP                                                       WING
      F(J,2)=F(J,2)+DELF(J)                                             WING
      U(J,2)=U(J,2)+DELU(J)                                             WING
      V(J,2)=V(J,2)+DELV(J)                                             WING
      G(J,2)=G(J,2)+DELG(J)                                             WING
      W(J,2)=W(J,2)+DELW(J)                                             WING
      T(J,2)=T(J,2)+DELT(J)                                             WING
    3 CONTINUE                                                          WING
      RETURN                                                            WING
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - WING
C                                                                       WING
C                                                                       WING
    4 FORMAT (1H0,1X,2HIT,4X,5HVWALL,9X,5HDELVW,9X,5HTWALL,9X,5HDELTW)  WING
    5 FORMAT (1H ,I3,4E14.6)                                            WING
      END                                                               WING
      SUBROUTINE SOLV2                                                  WING
      COMMON /BLC0/ NZT,NZ,NP,IT,X,RDES,CMACH,TT,ETA(101),DETA(101),A(10WING
     11),Y(101)                                                         WING
      COMMON /BLC1/ HE,PR,CMUES,UES,CEL(51),BETA1(51),UE(51),WE(51),Z(51WING
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),RR(WING
     251),BLP(51)                                                       WING
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,WING
     12),T(101,2),B(101,2),C(101),BG(101,2),E(101,2),DENR(101,2),CA1(101WING
     2,2),CA2(101,2)                                                    WING
      DIMENSION S1(101), S2(101), S3(101), R1(101), R2(101), Y1(101), Y2WING
     1(101), B11(101), B12(101), A11(101), A12(101)                     WING
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - WING
C     BOUNDARY CONDITIONS                                               WING
      BC(NP,2)=1.0                                                      WING
      ALFA0=0.0                                                         WING
      ALFA1=1.0                                                         WING
      GAMMA0=0.0                                                        WING
      BETA0=1.0                                                         WING
      BTA1=0.0                                                          WING
C                                                                       WING
      DO 2 J=2,NP                                                       WING
      FB=0.5*(F(J,2)+F(J-1,2))                                          WING
      GB=0.5*(G(J,2)+G(J-1,2))                                          WING
      WB=0.5*(W(J,2)+W(J-1,2))                                          WING
      IF (NZ.GT.1) GO TO 1                                              WING
C                                                                       WING
```

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      CFB=0.0
      CGB=0.0
      CWB=0.0
      CEB=0.0
C     - ATTACHMENT-LINE FLOW
      S1(J)=CA1(J,2)+A(J)*(-1.5*FB+P1(NZ)*GB-BLP(NZ))
      S2(J)=-CA1(J-1,2)-CA1(J,2)+S1(J)
      S3(J)=0.0
      R1(J)=CA2(J-1,2)-CA2(J,2)
      R2(J)=0.0
      GO TO 2
C
1     CFB=0.5*(F(J,1)+F(J-1,1))
      CGB=0.5*(G(J,1)+G(J-1,1))
      CWB=0.5*(W(J,1)+W(J-1,1))
      CEB=0.5*(E(J,1)+E(J-1,1))
      CBGB=0.5*(BG(J,1)+BG(J-1,1))
C
C     - GENERAL ENERGY EQUATION
      S1(J)=CA1(J,2)+A(J)*(-1.5*FB+P3(NZ)*GB+CEL(NZ)*(GB-CGB)-BLP(NZ))
      S2(J)=-CA1(J-1,2)-CA1(J,2)+S1(J)
      S3(J)=-A(J)*CEL(NZ)*(WB+CWB)
C
      DERCA1=(CA1(J,1)*E(J,1)-CA1(J-1,1)*E(J-1,1))/DETA(J-1)
      DERCA2=((CA2(J,2)-CA2(J-1,2))/DETA(J-1))+((CA2(J,1)-CA2(J-1,1))/DE
     1TA(J-1))
      CLBE=DERCA1-1.5*CFB*CEB+P3(NZ-1)*CGB*CEB-BLP(NZ-1)*CEB
      R1(J)=DETA(J-1)*(-CLBE+CEL(NZ)*(-CBGB*(WB+CWB)-(GB-CGB)*CEB)-DERCA
     12)
      R2(J)=0.0
2     CONTINUE
      R2(NP)=1.0
C
      R1(1)=GAMMA0
      R2(1)=0.0
      B11(1)=ALFA0
      B12(1)=ALFA1
      Y1(1)=R1(1)
      Y2(1)=R2(1)
      DO 3 J=2,NP
C     CALCULATION OF GAMMA AND W VECTORS
      A11(J)=(S2(J)-A(J)*S3(J))/(B12(J-1)-A(J)*B11(J-1))
      A12(J)=B11(J-1)*A11(J)-S3(J)
C     CALCULATION OF ALFA COEFFICIENTS
      B11(J)=S3(J)-A12(J)
      B12(J)=S1(J)+A12(J)*A(J)
      Y1(J)=R1(J)-A11(J)*Y1(J-1)-A12(J)*Y2(J-1)
      Y2(J)=R2(J)
```

```
3     CONTINUE                                                          WING
C     CALCULATION OF PERTURBATION QUANTITIES                            WING
C     WHEN THE OUTER B.C. GIVEN                                         WING
      BG(NP,2)=B2(NP)                                                   WING
      E(NP,2)=(Y1(NP)*BETA0-B11(NP)*Y2(NP))/(B12(NP)*BETA0-B11(NP)*BTA1)WING
      J=NP                                                              WING
4     J=J-1                                                             WING
      PAP1=Y2(J)-BG(J+1,2)+A(J+1)*E(J+1,2)                              WING
      E(J,2)=(Y1(J)+B11(J)*PAP1)/(-A(J+1)*B11(J)+B12(J))                WING
      BG(J,2)=-A(J+1)*E(J,2)-PAP1                                       WING
      IF (J.GT.1) GO TO 4                                               WING
      RETURN                                                            WING
      END                                                               WING
      SUBROUTINE OUTPUT                                                 WING
      COMMON /BLCO/ NZT,NZ,NP,IT,X,ROES,CMACH,TT,ETA(101),DETA(101),A(10WING
     11),Y(101)                                                         WING
      COMMON /BLC1/ HE,PR,CMUES,UES,CEL(51),BETA1(51),UE(51),WE(51),Z(51WING
     1),PE(51),PHI(51),RHOE(51),XC(51),CMUE(51),P1(51),P3(51),P4(51),RR(WING
     251),BLP(51)                                                       WING
      COMMON /PROF/ DELV(101),F(101,2),U(101,2),V(101,2),G(101,2),W(101,WING
     12),T(101,2),B(101,2),C(101),BG(101,2),E(101,2),DENR(101,2),CA1(101WING
     2,2),CA2(101,2)                                                    WING
      DIMENSION TRANU(101), TRANY(101), DERW2(101), DERU2(101)          WING
      DIMENSION DERU1(101),DERW1(101),DERT1(101),DERT2(101),TRANW(101)  WING
      COMMON /PAP/ IWRT,A1,A2,A3,VGP                                    WING
C     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - WING
      RX=RHOE(NZ)*UE(NZ)*X/CMUE(NZ)                                     WING
      QE=SQRT(UE(NZ)**2+WE(NZ)**2)                                      WING
      SQRX=SQRT(RX)                                                     WING
      PAP3=X/SQRX                                                       WING
      SUM=0.0                                                           WING
      F1=DENR(1,2)                                                      WING
      Y(1)=0.0                                                          WING
      DO 1 J=2,NP                                                       WING
      F2=DENR(J,2)                                                      WING
      SUM=SUM+(F1+F2)*A(J)                                              WING
      F1=F2                                                             WING
      Y(J)=SUM*PAP3                                                     WING
1     CONTINUE                                                          WING
      JFLAG=0                                                           WING
      KFLAG=0                                                           WING
      DO 3 J=2,NP                                                       WING
      IF (W(J,2).GT.1..AND.JFLAG.EQ.0) JFLAG=1                          WING
      IF (JFLAG.EQ.1) W(J,2)=1.0                                        WING
      IF (U(J,2).GT.1..AND.KFLAG.EQ.0) KFLAG=1                          WING
      IF (KFLAG.EQ.1) U(J,2)=1.0                                        WING
3     CONTINUE                                                          WING
      CID=SUM                                                           WING
```

```
      WRITE (6,19)
      WRITE (6,20) (J,ETA(J),F(J,2),U(J,2),V(J,2),G(J,2),W(J,2),T(J,2),D
     1ENR(J,2),Y(J),J=1,NP,3)
      WRITE (6,20) NP,ETA(NP),F(NP,2),U(NP,2),V(NP,2),G(NP,2),W(NP,2),T(
     1NP,2),DENR(NP,2),Y(NP)
      DELSTX=PAR3*(-F(NP,2)+CID)
      DELSTZ=PAR3*(-G(NP,2)+CID)
      DSTZINC=DELSTZ
      SUM=0.0
      SUM2=0.0
      F1=U(1,2)*U(1,2)
      F11=W(1,2)*W(1,2)
      DO 4 J=2,NP
      F2=U(J,2)*U(J,2)
      F22=W(J,2)*W(J,2)
      SUM=SUM+(F1+F2)*A(J)
      SUM2=SUM2+(F11+F22)*A(J)
      F1=F2
      F11=F22
    4 CONTINUE
      THETAX=PAR3*(F(NP,2)-SUM)
      THETAZ=PAR3*(G(NP,2)-SUM2)
      CFX=2.0*C(1)*V(1,2)/SQRX
      HX=DELSTX/THETAX
      HZ=DELSTZ/THETAZ
      IF (CMACH.EQ.0.0) GO TO 5
      TE=PE(NZ)/RHOE(NZ)/1716.0
      TW=TE*DENR(1,2)
      RHOW=RHOE(NZ)/DENR(1,2)
      GO TO 6
    5 TE=TT
      TW=TT
      RHOW=ROES
    6 VW=BLP(NZ)*SQRT(UE(NZ)*CMUE(NZ)*RHOE(NZ)/X)/RHOW
      IF (NZ.GT.1) GO TO 7
      CFZ=0.0
      SQUIG=BLP(1)/SQRT(P1(1))
      GO TO 8
    7 CFZ=2.0*C(1)*T(1,2)*UE(NZ)/WE(NZ)/SQRX
      SQUIG=BLP(NZ)*SQRT(PR(NZ)*UE(NZ)/WE(NZ)/X)
    8 WRITE (6,21) DELSTX,DELSTZ,THETAX,THETAZ,CFX,CFZ,HX,HZ
      WRITE (6,18) UE(NZ),WE(NZ),PE(NZ),TE,RHOE(NZ),CMUE(NZ),BLP(NZ),SQU
     1IG,TW,RHOW,VW,C(1)
      IF (NZ.EQ.1) GO TO 12
      DO 9 J=1,NP
      TRANU(J)=U(J,2)*UE(NZ)/WE(NZ)
      TRANY(J)=Y(J)/DSTZINC
    9 CONTINUE
```

```
      NPM1=NP-1
      DO 10 J=2,NPM1
      DY1=TRANY(J)-TRANY(J-1)
      DY2=TRANY(J+1)-TRANY(J)
      DERU2(J)=(DY1*TRANU(J+1)+DY2*TRANU(J-1)-TRANU(J)*(DY1+DY2))/(.5*DY
     11*DY2*(DY1+DY2))
      DERW2(J)=(DY1*W(J+1,2)+DY2*W(J-1,2)-W(J,2)*(DY1+DY2))/(.5*DY1*DY2*
     1(DY1+DY2))
      DERT2(J)=(DY1*DENR(J+1,2)+DY2*DENR(J-1,2)-DENR(J,2)*(DY1+DY2))/
     1(.5*DY1*DY2*(DY1+DY2))
      DERU1(J)=(DY1**2*TRANU(J+1) -(DY1**2-DY2**2)*TRANU(J)-DY2**2*
     1TRANU(J-1))/(DY1+DY2)/DY1/DY2
      DERW1(J)=(DY1**2*W(J+1,2)-(DY1**2-DY2**2)*W(J,2)-DY2**2*W(J-1,2))
     1/(DY1+DY2)/DY1/DY2
      DERT1(J)=(DY1**2*DENR(J+1,2)-(DY1**2-DY2**2)*DENR(J,2)-DY2**2*
     1DENR(J-1,2))/(DY1+DY2)/DY1/DY2
10    CONTINUE
      DERU2(NP)=(TRANU(NP-1)-TRANU(NP))/DY2**2
      DERW2(NP)=(W(NP-1,2)-W(NP,2))/DY2**2
      DERT2(NP)=(DENR(NP-1,2)-DENR(NP,2))/DY2**2
      DERU1(NP)=(TRANU(NP)-TRANU(NP-1))/2./DY2
      DERW1(NP)=(W(NP,2)-W(NP-1,2))/2./DY2
      DERT1(NP)=(DENR(NP,2)-DENR(NP-1,2))/2./DY2
      X1=TRANY(2)
      X2=TRANY(3)
      X3=TRANY(4)
      X4=TRANY(5)
      DL0=X1*X2*X3*X4
      AA2=X1*X2+X1*X3+X2*X3+X1*X4+X2*X4+X3*X4
      B2=X2*X3+X2*X4+X3*X4
      DL1=X1*(X1-X2)*(X1-X3)*(X1-X4)
      C2=X1*X3+X1*X4+X3*X4
      DL2=X2*(X2-X1)*(X2-X3)*(X2-X4)
      D2=X1*X2+X1*X4+X2*X4
      DL3=X3*(X3-X1)*(X3-X2)*(X3-X4)
      F2=X1*X2+X1*X3+X2*X3
      DL4=X4*(X4-X1)*(X4-X2)*(X4-X3)
      DERW2(1)=2.*B2*W(2,2)/DL1+2.*C2*W(3,2)/DL2+2.*D2*W(4,2)/DL3+2.*F2*
     1W(5,2)/DL4
      DERU2(1)=2.*B2*TRANU(2)/DL1+2.*C2*TRANU(3)/DL2+2.*D2*TRANU(4)/DL3+
     12.*F2*TRANU(5)/DL4
      DERT2(1)=2.*B2*DENR(2,2)/DL1+2.*C2*DENR(3,2)/DL2+2.*D2*DENR(4,2)/
     1DL3+2.*F2*DENR(5,2)/DL4
      DERT2(1)=DERT2(1)+2.*AA2*DENR(1,2)/DL0
      DY1=TRANY(2)-TRANY(1)
      DY2=TRANY(3)-TRANY(2)
      DERU1(1)=(TRANU(2)*(DY1+DY2)/DY1-TRANU(3)*DY1/(DY1+DY2))/DY2
      DERW1(1)=(W(2,2)*(DY1+DY2)/DY1-W(3,2)*DY1/(DY1+DY2))/DY2
        )
```

```
      DERT1(1)=(-DENR(1,2)*(X2**2-X1**2)+DENR(2,2)*X2**2-DENR(3,2)*
     1X1**2)/X1/X2/(X2-X1)
      RDSTZ=RHOE(NZ)*WE(NZ)*DSTZINC/CMUE(NZ)
      IF (IWPT.EQ.3) GO TO 12
      IF (IWPT.NE.0.AND.IWPT.NE.2) GO TO 11
      WRITE (7) NZ,NP,DSTZINC,RDSTZ
      WRITE(7)QE,PE(NZ),TE,RHOE(NZ),CMUE(NZ),TW,RHOW
   63 FORMAT(7E16.9)
      WRITE(7)(TRANY(J),J=1,NP)
      WRITE(7)(W(J,2),J=1,NP)
      WRITE(7)(DERW1(J),J=1,NP)
      WRITE(7)(DERW2(J),J=1,NP)
      WRITE(7)(TRANU(J),J=1,NP)
      WRITE(7)(DERU1(J),J=1,NP)
      WRITE(7)(DERU2(J),J=1,NP)
      WRITE(7)(DENR(J,2),J=1,NP)
      WRITE(7)(DERT1(J),J=1,NP)
      WRITE(7)(DERT2(J),J=1,NP)
   11 CONTINUE
      IF (IWPT.NE.1.AND.IWPT.NE.2) GO TO 12
      WRITE (6,16) NZ,NP,DSTZINC,RDSTZ
      WRITE (6,17)
      ISTEP=1
      WRITE (6,15) (J,TRANY(J),W(J,2),DERW1(J),DERW2(J),TRANU(J),
     1DERU1(J),DERU2(J),DENR(J,2),DERT1(J),DERT2(J),J=1,NP,ISTEP)
   12 CONTINUE
C
C     SHIFT PROFILES
      DO 13 J=1,NP
      F(J,1)=F(J,2)
      U(J,1)=U(J,2)
      V(J,1)=V(J,2)
      G(J,1)=G(J,2)
      W(J,1)=W(J,2)
      T(J,1)=T(J,2)
      B(J,1)=B(J,2)
      DENR(J,1)=DENR(J,2)
      IF (CMACH.EQ.0.0) GO TO 13
      E(J,1)=E(J,2)
      BG(J,1)=BG(J,2)
      CA1(J,1)=CA1(J,2)
      CA2(J,1)=CA2(J,2)
   13 CONTINUE
C
      NZ=NZ+1
      RETURN
C     ----------------------------------------------------------------
C
      )
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16. Abstract

A fast computer code COSAL for transition prediction in three-dimensional boundary layers using compressible stability analysis is developed. The compressible stability eigenvalue problem is solved using a finite-difference method and the code is a black-box in the sense that no guess of the eigen-value is required from the user. Several optimization procedures are incorporated in COSAL to calculate integrated growth rates (N factor) for transition correlation, for swept and tapered laminar flow control wings, using the well known e^N method.

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